EC Project 610829

A Decarbonisation Platform for Citizen Empowerment and Translating

Collective Awareness into Behavioural Change

D5.3.1: Use Case 1 - Evaluation Report v1

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Version history

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Executive Summary

This report refers to the first version of the deliverable *D5.3.1: Use Case 1 Evaluation Report*. This first DecarboNet use case sheds light on the Energy Trial, an initiative to engage people with energy savings by distributing energy monitors and providing recommendations to reduce carbon emissions.

In *D5.2 Energy Trial Application*, we provided an overview of the first version of the Citizen Engagement application, describing its design principles and functionalities. In this document, we report the outcome of evaluating the first version, then we describe the final version of the application, and the user recruitment strategy and process. To date, nearly 381 users have registered to participate in the WP5 energy trials, and 150 of them were selected and sent energy monitoring devices, in addition to 810 users of GEO devices whose daily energy consumption data is now shared with DecarboNet to further support our research and experiments. Furthermore, a new version of the Climate Challenge application (see D3.1) is now being developed to enable its users to integrate and view their energy consumption readings.

Users of this application will be able to create and share energy-saving recommendations, drawn from the knowledge they extract from using smart plugs in their home or office environment. Our periodic energy saving campaigns will suggest different appliances (or different usage contexts) to trigger new discussions. Users' online behaviour that relates to energy consumption will be analysed to understand how the technology influences collective awareness and behaviour change.

Four steps compose the Energy Trial setup and evaluation. We summarise here the strategies applied in each of them:

(1) Distribution of the energy monitors to representative groups of users. The Energy Trial was advertised through multiple online channels, reaching people from different geographic areas and social contexts. In this first stage of the Trial, 3 groups of 50 people in the UK were recruited to start using the energy monitors.

(2) Design of the collaborative awareness platform for generating and sharing energy-saving recommendations. Results of preliminary evaluations of the first application prototype (D5.2) indicated the need to review several design characteristics of the Citizen Engagement Platform prototype. Engaging characteristics needed to be enhanced, such as promoting dialogue and broadening the scope of themes to be discussed, in additional to new interface design and user experience.

(3) Promotion of energy saving campaigns. Stakeholders have been contacted to establish collaboration on disseminating energy saving campaigns. The reached stakeholders and the first contact outcomes are described in this report.

(4) Analysis of energy consumption data. Consumption data and online behaviour will be analysed together to provide insights around social technology

and behaviour change. Some preliminary analysis related to smart plug data patterns and constraints are provided in this report, to establish the basis for further behaviour-change analysis (see also D4.1: Behaviour Analysis and Prediction).

1 Introduction

The first DecarboNet use case (WP5) refers to the Energy Trial, a citizen-centred initiative to raise collective awareness of energy consumption. Monitoring appliances' electricity consumption in the domestic environment and sharing related-experiences through social media are the main objectives pursued in terms of citizen engagement. The literature [16], and our early energy experiments [11,18] (D1.1.1, D1.2) pointed directions to setup this user-centred study. Four main steps have been taken, in accordance with the initial project plans, to deploy the Energy Trial:

1. Provide participants with energy monitoring devices by GEO. 250 devices have been provided to the project, and 150 of them have been distributed to recruit individuals and households to the project energy trial, and to monitor their energy use via GEO's in-home displays and the WP5 applications. The further 100 devices were saved for distribution in year 3 of the project.
2. Develop a carbon reduction methodology to guide the development and deployment of the WP5 applications and energy trials (D1.1.1);
3. Organise and promote energy saving campaigns to raise collective awareness, in the form of competition and collaborative actions through social media campaigns.
4. Investigate methods to track and nudge user engagement to assess impact of the deployed technology on behaviour.

With a grassroot approach, people in the United Kingdom and Europe have been invited to sign-up to the DecarboNet Energy Trial. Selected people received free energy monitoring devices that will be used as learning tools for building a collective knowledge repository on energy saving tips.

In line with the four WP5 main objectives, this first version of the report summarises: 1) the strategies applied to distribute the energy monitors; 2) design features to engage users with the online platform targeting the generation of energy saving recommendations; 3) Contacts with stakeholders to set up energy saving campaigns; 4) First insights into energy consumption data analysis (connection with WP4).

2 Providing eco-feedback

To provide participants with eco-feedback on electricity consumption in their households, 250 sets of devices were made available by GEO to be freely distributed. In the next section we describe the device's' specifications and the criteria/process we followed for distributing them.

2.1 The electricity monitors

The Ensemble monitoring kit offered by GEO for the Energy Trial[1] is composed by:

- Sensor and transmitter

[1] The devices are featured with the UK standard energy plug. They can be installed in Europe with plug adapters.

- Display
- Smart Plug
- Web pack (Internet bridge)

The **sensor** and **transmitter** measure the consumption at the household meter and transmit it to the **display** (Figure 1a) wirelessly. The **smart plugs** (Figure 1b) measure the consumption of individual appliances and also transmit this to the display wirelessly. Users can also view the consumption history and control appliances online through the service **energynote**, which requires the installation of the **web pack** (Figure 1c), also included in the kit. The Internet bridge of the web pack connects wirelessly to the display and to a broadband router via Ethernet cable.

a. display b. smart plug c. web pack (Internet bridge)

Figure 1 – DecarboNet Electricity Monitoring kit

Energynote (https://www.energynote.eu) provides a graphical representation of real-time energy usage as well as an analysis of the historical data reported by the in-home display and smart plugs, covering energy consumption in energy units (kWh), kg CO_2 or currency, and cost compared to budget. There are no separate apps to download to view from a smartphone and the service works with modern browsers on all of the major computing and smartphone platforms. More details on the features available and installation process can be seen in the technical support documents available online [8].

2.1 Recruiting participants

Beyond the interest in saving energy in the household, it is also desirable that participants of the Energy Trial would have some degree of familiarity - and interest - in online and social applications (or an external support for using ICTs when necessary). This way we can be sure that they will be able and motivated to fully explore the benefits of energynote and the Citizen Engagement Platform developed by DecarboNet.

The participants recruiting process was focused on the online channels, and consisted of two 2 phases:

1. Expression of interest
2. Users group formation

2.1.1 Expression of Interest

To discover the level of potential interest in taking part in the Energy Trial, the initiative was promoted online mainly via:

- The **Open University Intranet**, reaching the University's staff not only in the Milton Keynes area, where the main campus is, but also in other areas of the United Kingdom.
- The **Sheffield University's Volunteering** channels. A Portal and mailing list dedicated to promote surveys and research projects that students can volunteer to take part.
- **GEO** staff. Small selection of interested people from GEO (not involved in DecarboNet) were invited to be part.
- **WAAG Society website and Intranet**. It reaches officers and general public in the Netherlands.
- **Twitter**: to followers of @DecarboNet and of the personal accounts of the project team members.
- **General public and stakeholders**: both groups related to social/renewable energy and environmentalists were contacted and asked to disseminate the initiative. These groups tend to be already interested in conserving energy, and motivated to engage other people to help disseminate the initiative beyond the academic environment.

The following text was used for the dissemination of the Energy Trial:

(short version)

> *If you are a social media fan and are interested in energy savings, you can apply for free energy monitors and smart plug from the European project DecarboNet: http://goo.gl/forms/5TiydBt5E8*

(long version)

> ## *Engage with energy savings*
>
> *Are you keen to learn more about the consumption of your appliances?*
> *Do you like to share good ideas among your friends?*
> *You can apply for receiving free energy monitors (and smart plugs) from the project DecarboNet.*
> *You will be able to check online the consumption for the whole house, or for individual devices, activate/deactivate a plug remotely, and compare your consumption with others.*
>
> *To participate, you must:*
> *1. Be older than 18*
> *2. Live in Europe (plug adapter may be needed outside of the UK)*
> *3. Have Internet at home (with a hub - you'll need to plug a network cable)*
>
> *And what we expect from you is that want to become more aware of how much energy is used around your house, and* ***to learn/share your experiences with others.***

To apply, please fill in this form: http://goo.gl/forms/9YNtFJJxmP

The online form (Google form) first reinforced the 3 main conditions of being older than 18, to live in Europe, and to have an Internet hub at home, then collected name, location, age, and email address (Figure 2) of interested people for further contact.

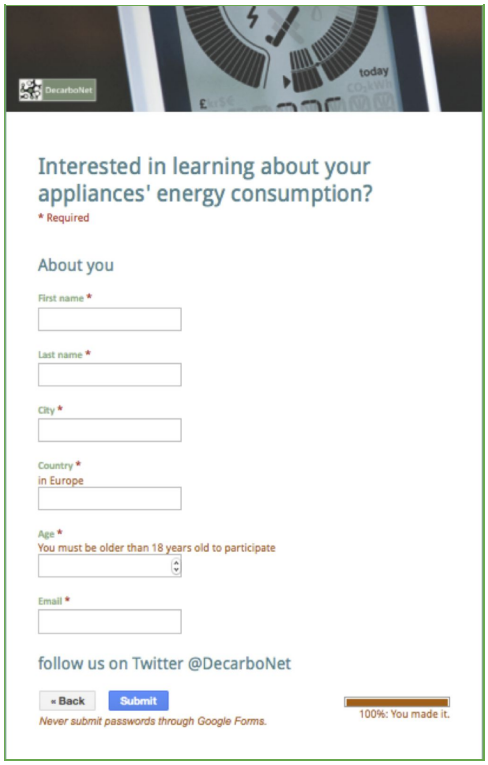


Figure 2 – Online form to collect contact of interested people

From 07/07/2015 to 20/09/2015, a total of 381 people filled the form expressing their interest in being engaged with the Energy Trial.

People from different contexts and geographical locations subscribed. The top ten cities where interested people live are listed in Table 1. With the exception of Amsterdam and Utrecht that are in the Netherlands, the other 8 cities/towns are located in the UK.

Table 1 - People interested in the Energy Trial per cities

	City	Nr of people
1	Sheffield	165
2	Milton Keynes	36
3	Amsterdam	20
4	Cambridge	10

5	London	10
6	Utrecht	9
7	Barnsley	8
8	Rotherham	6
9	Chesterfield	4
10	Southampton	3

Figure 3, below, illustrates the distribution of interested users by geographic area groups, considering:

- SH: Sheffield and surroundings (52%)
- MK: area around Milton Keynes (13%)
- UK: Other areas in the UK out of Sheffield of Milton Keynes neighborhood (20%)
- NL: The Netherlands (11%)
- EU: other countries in Europe beyond the Netherlands (4%)

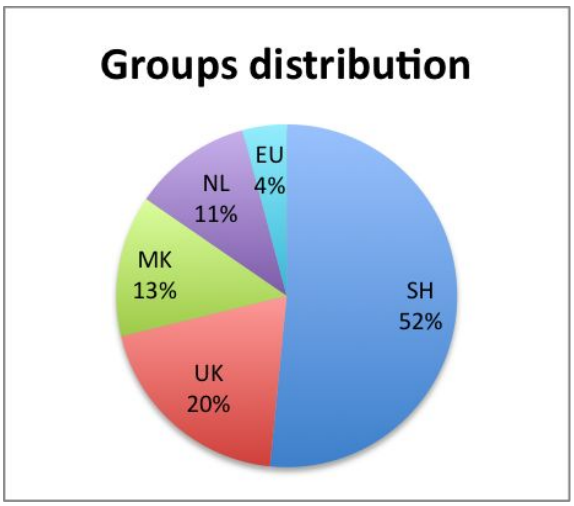


Figure 3 – Geographic groups of interested people

2.1.2 Users group formation

The selection of participants and device distribution have been planned to take place in two phases. The strategy is to establish significative groups to have consumption and behavioural data analysed and compared.

- **Phase 1**: 150 people, distributed over 3 main groups of 50 participants each: SH, MK, and UK. The Netherlands and other countries in Europe were not initially considered to prevent that practical constraints related to the plug adapter (and the need of extra physical space to fit them with the appliances) and the language (the user-generated content is expected to be in English)

compromise the engagement in the crucial moment of launching the online platform. However, involving users from outside the UK is planned for Year 3 of the project. Note that users of the Climate Challenge application are distributed worldwide.

- **Phase 2:** Will be more focused on existing communities, creating the link between online and physical communities. Some of the 100 remaining devices will be distributed following this criteria.

Subgroups of people that declared interest were contacted until 50 in each of the 3 groups confirmed their interest online. The confirmation happened by accepting the Terms and Conditions and proving the address to receive the devices.

The Terms and Conditions presented and accepted by the participants is described as follows:

Terms and conditions

** The project*

DecarboNet is a project funded by the European Commission that aims to raise people's awareness of their energy consumption behaviour. The project also investigates methods for influencing change in this behaviour. Understanding how energy consumption behaviour can be changed, for short and long term, can help to optimise energy use, which is one crucial step in the global battle against climate change.

** What participants can expect*

This study is intended to develop methodologies to bring about behavioural change with regards to energy use. Participants will take part in a study of energy use in and around the home environment.

Participants will receive the Ensemble electricity monitor by Green Energy Options (geo) composed by: display, sensor to be clipped close to the energy meter, transmitter, Internet bridge, and 1 smart plug. After the study, participants can retain the equipment received.

Participants are expected to install the smart plug, Internet bridge and display at home, and to configure an Energynote account to monitor consumption online. Clipping the sensor and transmitter to monitor the overall consumption in the house is optional.

Participants are expected to engage with the web portal that will be launched by the project by sharing experiences (not consumption data) and hints around monitoring appliances, especially those suggested in the portal as the current theme. Making questions, comments, and supporting other peoples' ideas are encouraged actions. Spreading knowledge through Facebook/Twitter too.

The study using the energy monitors and social media will be conducted along the project, until October of 2016.

** What is done with the results*

Participants will be asked to share the consumption data with the project and answer an online survey reporting their experience.

Data collected will be kept secure and shared only anonymously amongst DecarboNet partners, which uphold the same confidentiality agreement. Analysed data can be used in an anonymous way in written reports, presentations and published papers relating to this study.

** Permission*

Completing this form indicates that you complies with the requirements to participate, understand the purpose of the research, accept to install the energy monitoring equipment, and the conditions for handling the data you provide.

For building a panorama of the participants in terms of current energy consumption and motivations for saving energy, they were asked to report the number of people resident in the house, to estimate their monthly bill, and to express in few words their main interest in monitoring energy.

The charts below (Figures 4 and 5) represent the results in terms of number of people sharing the households and monthly cost with energy, respectively. The dominance of houses with 2 people, and our average of 2.6 people per house, is well inline with the average household size in the UK which is 2.3 people per household [15]. This shows that our sampling is a good representative of the typical UK household in terms of size.

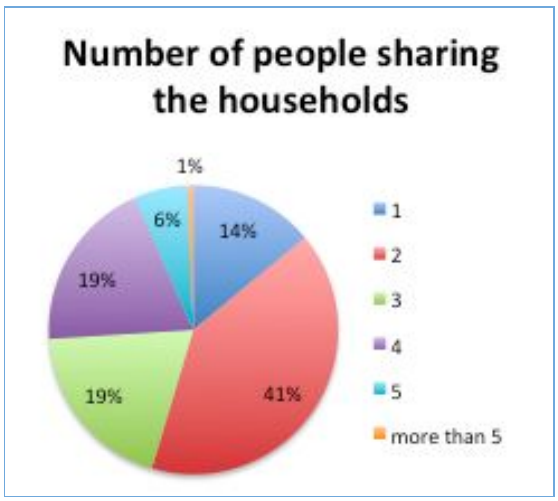


Figure 4 – Distribution of households' size

Majority of our participants (93%) were able to report their monthly consumption (Figure 5), which suggests a certain degree of awareness and/or interest with respect to energy usage in the household by the participants. This number, though, is just an indicator considering the multitude of variables that influence the amount paid monthly on gas and electricity, such as the season/weather, type of the house, type

of insulation and appliances, and so on. However, as a rule of thumb, it is known that a person would pay around £40 per month for using energy in the UK [4].

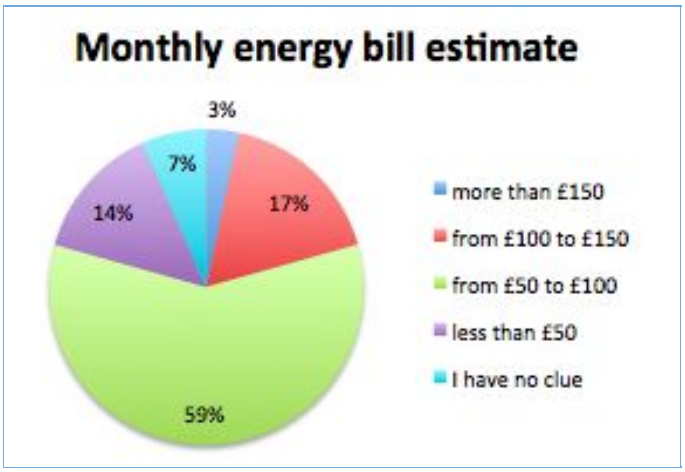


Figure 5 – Distribution of the amount spent monthly with energy

Considering the value of £40/person as a reference, the analysis of the chart in Figure 6, suggests, roughly, that couples/individuals consuming mostly around the average and families (more than 3 people in the house) are consuming predominantly below the average. Few participants in general are above the average with regards to energy monthly bills. Further analysis is necessary to confirm eventual patterns of consumption in the Energy Trial.

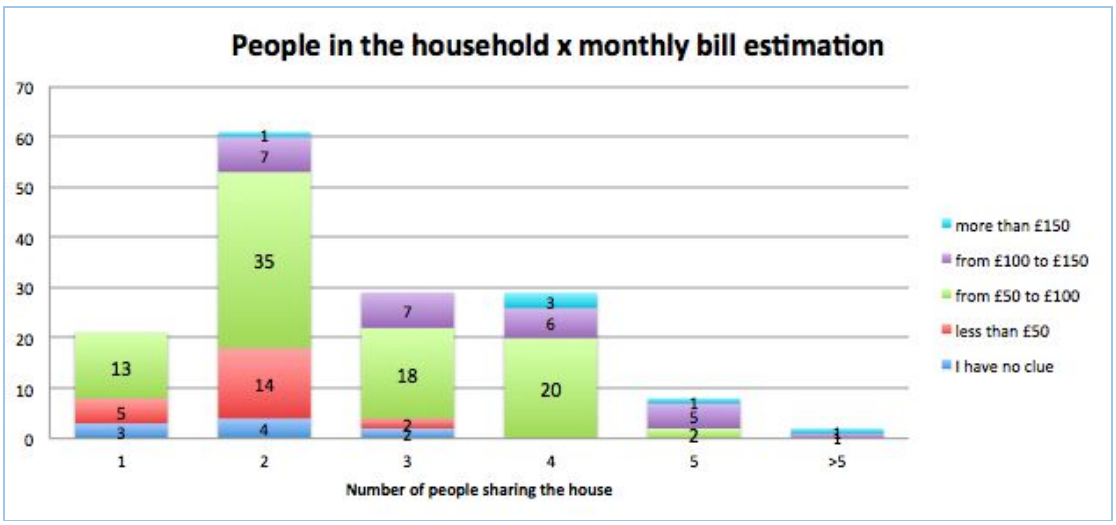


Figure 6 – Number of people in the household and estimate cost of the energy bill

Figure 7 presents the tag cloud with the most frequent words in the participants' response to what their main interest in monitoring their electricity consumption is. To **reduce** consumption is the main target. Although **bill** and **costs** had a high frequency, **understand**, **learn, identify,** are also present, in line with the Energy Trial

purpose. The words energy and electricity were the most frequent naturally, which we removed of the tag cloud below to improve the perception of the other terms.

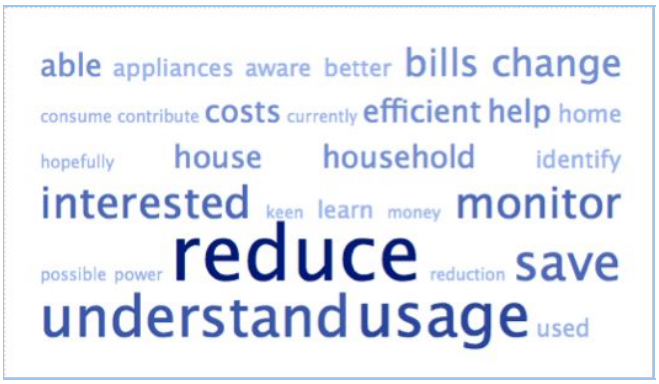


Figure 7 – Tag cloud with the most frequent words in the participants' interest in monitoring consumption

In the current moment, the first 150 devices have been shipped/delivered. The users will be invited to join the Citizen Engagement Platform in its latest version, as described in next section.

3 Promoting user-generated carbon reduction recommendations

To better understand the role and potential of social media in engaging users in the topic of energy consumption, we produced and disseminated an online questionnaire which was answered by 212 people. From this online survey [17], we learnt that social media does not appear to be a common place where people gathered for information related to energy savings and climate change. They appear to prefered to go to the general news or dedicated portals instead for acquiring such information. Nevertheless, by gathering people sharing similar interests and easily spreading worldviews and new social norms, social networks are known to have an influence on people's opinion and engagement [7]. Boosting user-generated content, in a personal approach, is therefore a potentially effective strategy for promoting energy-saving topics and behaviour on social media in the Energy Trial.

People who answered the survey represent the set of people we reached when promoting the Energy Trial. They stated to use Facebook much more than Twitter (66.6% posts on Facebook at least every few weeks, while 28.2% posts on Twitter). However, Facebook is often used for very personal content, and hence perhaps should not be the only place for promoting the sharing of carbon reduction recommendations with other people in the Energy Trial.

The Citizen Engagement Portal has been conceived as a new online social space for sharing and hosting carbon reduction recommendations related to energy savings generated mainly, but not exclusively, by the Energy Trial participants. It has been developed under a user-centred approach as described in [3] and published in [18].

3.1 Design progress and evaluations

Application design, development, and evaluation is as an iterative process. The prototype described in D5.2 [3] is the initial version of the Citizen Engagement portal. Since then, the application went through a major revision, in light of a first usability and engagement evaluation exercise.

Figure 8 illustrates this transformation process from the (1) conceptual version, to (2) the prototype which was launched during Earth Hour 2015, and to (3) the final version to be launched for COP21 and subsequently for Earth Hour 2016 (with revision based on COP21-launch experience).

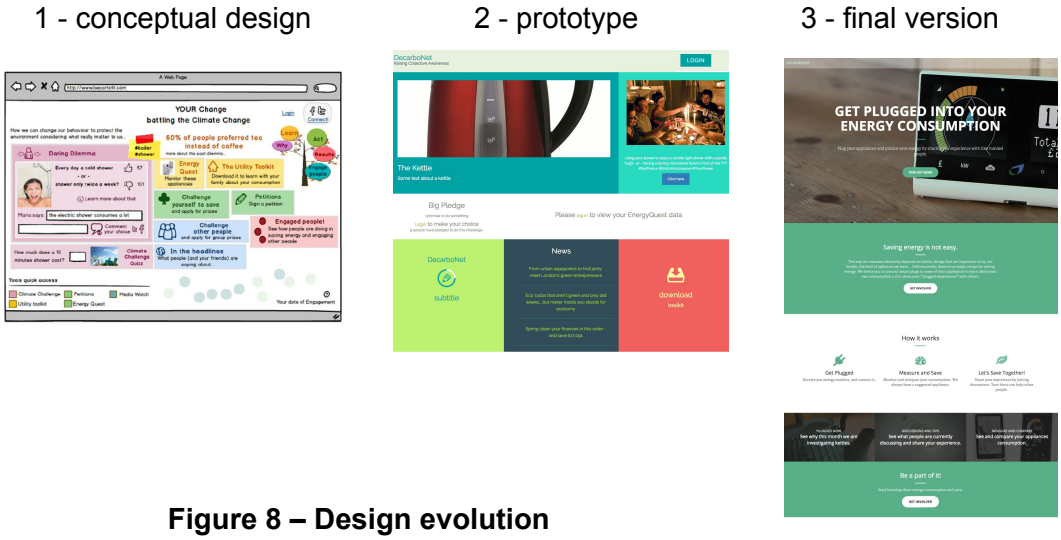


Figure 8 – Design evolution

The first prototype was launched during Earth Hour 2015, to raise awareness to the project, and to the Citizen Engagement application. The prototype consists of a number of widgets as fully described in D5.2. Google analytics below (Figure 9) shows that the prototype was visited by 101 unique users, with about a half returning to the site more than once. Given the simplicity of the version released, these visitor numbers shows the promising level of interest. Since then, the application has gone through major revisions, and we have identified multiple new and highly effective channels for advertising the application during COP21 and Earth Hour 2016.

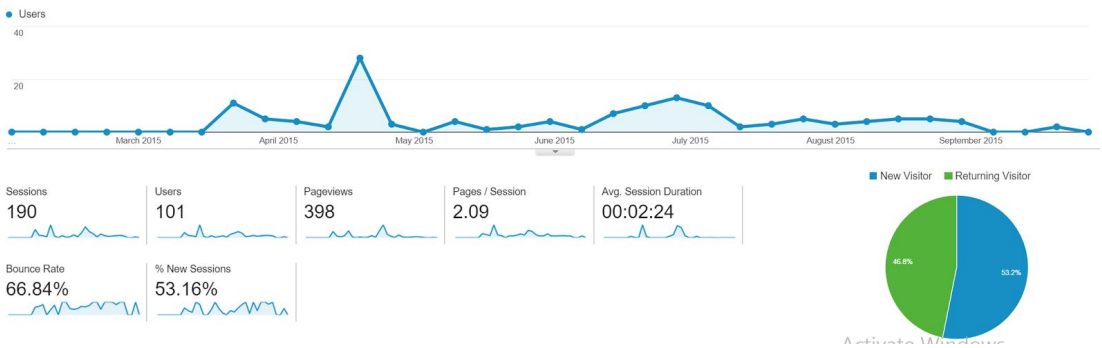


Figure 9 – Google analytics of the Citizen Engagement application

For collecting feedback from specialists, the conceptual design and prototype (Figure 8 - 1 and 2) were presented at the 2015 *British Human Computer Interaction Conference* as a poster [18], and also as part of the workshop *Sustainable HCI in the UK* held in the same conference. A few potential users from the Open University lab also provided feedback of their overall experience of the prototype.

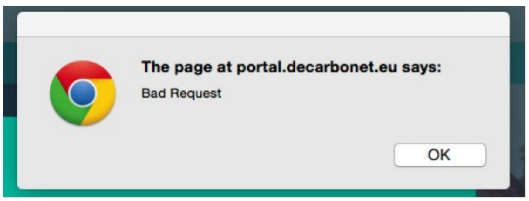
In Table 2 we summarise some of the general usability problems identified, some of which impacting the perception of the purpose of the WP5 platform of building collective knowledge around energy savings by sharing experiences. The analysis is inspired by the Nielsen's heuristics [14], a set of 10 general principles to guide usability inspection widely adopted by interaction design specialists. Beyond identifying problems, this method suggests setting severity ratings as:

1. **Cosmetic problem**: need not be fixed unless extra time is available on project
2. **Minor usability problem**: fixing this should be given low priority
3. **Major usability problem**: important to fix, so should be given high priority
4. **Usability catastrophe**: imperative to fix this before product can be released

Table 2 - Prototype's heuristic evaluation

Criteria (or heuristics) [14]	Problem found
1. Visibility of system status The system should always keep users informed about what is going on.	The platform should transmit the idea of being dynamic, constantly changed by new contributions by users and also by new periodic themes under discussion. Many users, though, had the perception that the platform was a static page about kettles – which was the chosen appliance for the month. *Severity: 4* Solutions: Bring users' discussions to the main page. Make more evident the variety of themes that can also be discussed.
2. Match between the system and the real world The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than in system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.	The references to Energynote or Energyquest in the main page were not understood by people out of that context, since they are services related to GEO devices. Some users had the perception that they were accessing some proprietary service instead of a space for discussions. *Severity: 3* Solutions: Create a landing page with initial explanations (illustrated) about the devices functioning and how it connects to the platform. Also, making it clear and evident that the content can be explored also by people not in the Energy Trial.
3. User control and freedom	Some components in the main page were taking the users out of the platform in an

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.	unexpected way. E.g.: the Daring dilemmas page leading to Facebook, the New leading to Media Watch. *Severity: 2* The connection with external accounts (Facebook and energynote) is a very important step. This process, though, needs to be suitable for corrections/modifications, undo, etc. These features will be enhanced in the new version. *Severity: 3*
4. Consistency and standards Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.	Some consistency problem were found mainly related to the use of terms Sign in, Login, etc. But they are not critical and could be easily corrected. *Severity: 2*
5. Error prevention Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.	Error prevention has not been exhaustively stressed/tested (see heuristic 9). *Severity: 4*
6. Recognition rather than recall Minimize the user's memory load by making objects, actions, and options visible.	The platform features a score system related to all the activities performed by the user. However, the functionality and purpose of this feature purpose is unclear. It should be visible at every related action, creating incentives to the user to get more engaged. Solution: Review rules and the design of this feature.. *Severity: 3*
7. Flexibility and efficiency of use Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.	The widget format in the main page is interesting to provide an overview of available features. However, the discussions are the main point of interest. It is a long way (in pages, number of mouse cliques) for the user in the main page get to the page where they can start a new post/comment. Users, mainly the frequent ones, should have the option to get directly to the discussion page, which should invite them to interact with previous posts or creating new ones. Solution: bring the more recent discussions to the main page. *Severity: 3*
8. Aesthetic and minimalist design Dialogues should not contain information irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.	

9. Help users recognize, diagnose, and recover from errors Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.	Generic messages as the one illustrated below were found when creating a new account.  Error messages and error preventions need to be exhaustively tested before making the system available to users, even if just to perform evaluations. *Severity: 3*
10. Help and documentation Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.	The About page provides general information about the project and the platform functioning. However, the platform brings a new concept of connecting electricity monitors (from an external service - energynote) to the social context, allowing sharing and comparison. Instructions clarifying how the energy monitor is connected are necessary. Additional information also needs to be provided to make users secure and confident that they can share experiences without compromise private data. *Severity: 2*

Based on the preliminary user experiments (D1.1.1, D1.2), a set of 7 design guidelines was defined in [3] (D5.2), and published in [18], pointing directions to the conception of the platform. These guidelines have been considered as starting pointing for the main principles for the decarbonisation methodology, under development in D1.1.2. In Table 3 we refer to this initial set of guidelines to discuss how some design decisions affected the original conception and purpose of the platform. We also present some solutions that have been addressed in the new version.

Table 3 - Analysis according to the DecarboNet design guidelines

Criteria [3]	Problems found and possible solutions
Emotional involvement Instead of guilt, people must feel comfortable to evaluate the trade-off between more environmentally friendly choices and individual values, such as comfort. The decision goes beyond users' rational choices.	The Daring Dilemmas were meant to bring into discussion possibilities for savings contrasting with related-personal values, expressing the emotional involvement. However, as revealed by our experiment on the Daring Dilemmas Facebook page, this initiative was not effective in triggering the desirable discussions. More investigation related to format and content of the dilemmas is necessary to make it more effective. Instead of pointing to the Dilemmas on Facebook, the new version will address related emotions/values by suggesting #hashtags that can be selected by the user to enrich their posts.
Personal approach Sharing personal experiences on saving energy or protecting the environment must be encouraged, instigating then the interest on social media as a source of practical information.	General hints to reduce consumption may not be applicable by everyone. Users need to find information relevant to their personal context, related to aspects of their everyday life. Filtering hints by hashtags that represent emotions, appliances and/or things related to lifestyle can lead users to a more personal approach.
Open space for discussion Exchanging experiences, ideas and freely expressing opinion about environment protection and energy saving are important ways to raise awareness collectively.	The blog component adopted by the preliminary version allows users to make comments on posts originated by the platform moderator. But the user did not necessarily feels invited to make a personal contribution. The collective/collaborative aspect is not enhanced. The format of debate (or forum), in which users can easily create new posts or vote for/against other posts, is more suitable to the purpose of the platform. Polls also play a role as a place for discussion, leading to actions.
Motivating engagement Protecting or improving the environment is rarely the primary motivation for people's pro-environmental behaviours, but may run concurrently. Desires to save money, promote health, avoid waste, be seen favourably by others, or by a sense of justice are also in play. Inciting and encouraging collective actions among groups to change behaviour were found as ways to motivate engagement.	Instead of relying only in one appliance as the current theme, the new version will connect appliances by "moments of life", such as "having breakfast" (relating kettle, toaster, microwave, etc.), "working in the office" (printer, monitors, etc.), " travelling", etc. This way, people can more easily identify habits or typical behaviour to be reviewed. It is more likely a user will find a relevant (motivating) topic to be discussed. References to previous topics/appliances discussed will also be enhanced on the main page.

Sensors as learning tools The main interest in using energy monitors is for learning the consumption of individual devices and appliances.	The sensors / energy monitors are the learning tools. By monitoring the consumption related to specific habits they can make sense of the impact and possible changes. But users who are not aware of what energynote is or how they work should feel comfortable to join the discussions too. A landing page has been design to provide this crucial information, especially for first time visitors.
Association with stages of behaviour change The investigations on behaviour change theory suggested the hypothesis that people in a different stage of behaviour change can benefit from specific incentives (or interventions), in the form of CEP functionalities, to move to next stages. This hypothesis is also driving the analysis of user-generated data on behaviour change to be performed in the WP4.	The widgets format, based on the conceptual design, follows the association between stages of behaviour change and features. This link seems to be adequate to the platform's purpose, but the user not necessarily needs to be aware of that, especially because features for every stage of behaviour will be always available. The new version will prioritise design features to promote engagement instead, leading users to the core features - posting - and giving a more dynamic character to the platform instead of representing this conceptual model. More details on the association between stages of behaviour change and features are discussed in the next section.

3.2 Behaviour change process

In D5.2 [3], we introduced the 5 Doors Theory of behaviour change [20], our main reference to understand information and interventions required to promote behaviour change in a collective way. The 5 stages of this theory are also in line with GEO's process model to disseminate social norms around energy efficiency in domestic environment. This empirical model called "Times Five" is described in D5.1 [2].

Reflecting the solutions to usability and engagement problems pointed out in Table 3, the mapping between stages of behaviour change and functionalities of the Citizen Engagement Platform presented in D5.2 [3] and [18] also had to be reviewed. In Table 4 we present the new mapping also evidencing the similarities between the Five Doors and the Times Five model.

In a broader perspective, this new mapping goes beyond The Citizen Engagement Platform functionalities, considering also complementary DecarboNet tools and strategies applied for the Energy Trial.

Table 4 - Stages of behaviour change and associated DecarboNet tools and features

Five Doors Stage [20]	Times Five Stage [2]	DecarboNet tools and features
1. Desirability Dealing with frustrations, wants, showing the need of a change	**Enrol:** establishing the means to generate and spread interest (otherwise it will not become a social norm)	- Promotion of the Energy Trial to Earth Hour and COP21 followers - Promotion of the Energy Trial to stakeholders - Link to the Climate Challenge (D3.1), which brings into discussion the impact of climate change and energy issues - Daring Dilemmas on Facebook. A page to attract people to the Citizen Engagement Platform from Facebook
2. Enabling context Providing conditions, understanding how to change behaviour	**Educate:** helping people to understand and gain confidence in their ability to manage their consumption	- Distribution of the energy monitors. - User-generated hints on energy savings on the Citizen Engagement Platform
3. Can do Improving self-efficacy	**Engage/execute:** to take actions, form routines and embed practices	- Periodic themes (or campaigns) on the Citizen Engagement Platform suggesting people to measure and review specific habits/appliances - Pledges associated to the campaigns both on the Platform and on the Climate Challenge - Link to related petitions to be signed, empowering the user (association with NGOs).
4. Buzz Encourage spreading successful stories	**Encourage:** to provide ongoing feedback and encouragement that in turn generates progress	- Challenge (pledge) other people: users can challenge people within their social network to change behaviour, evoking social norms, and peer pressure. - Stories and Hints: Encourage users to post their successful stories related to energy conservation. - Headlines: Visualisation on what other people in social networks are saying related to energy savings
5. Invitation Engage more people	**Expand/enhance:** to provide further steps and opportunities that build on early progress and creates momentum	- Sharing hints on social media (Twitter and Facebook), outside of the Citizen Engagement Platform, relying on personal social network to invite and engage more people. - Visualising engagement: visual representations of how people are getting engaged with the portal, and their performance in the challenges.

		- Running workshops with existing communities targeting collective actions.

3.3 New design of the Citizen Engagement Platform

The modifications above are now being introduced into the new version of the platform, as illustrated in Figure 10 with the appliances page (commented), and in Figure 11 with the "Moments of Life" page represented by the "breakfast". Appliances and emotional states will be connected to these *moments* as hashtags. The new design will be evaluated with end users as soon as a functional version is available.

Figure 10 – The appliances page on the new WP5 platform

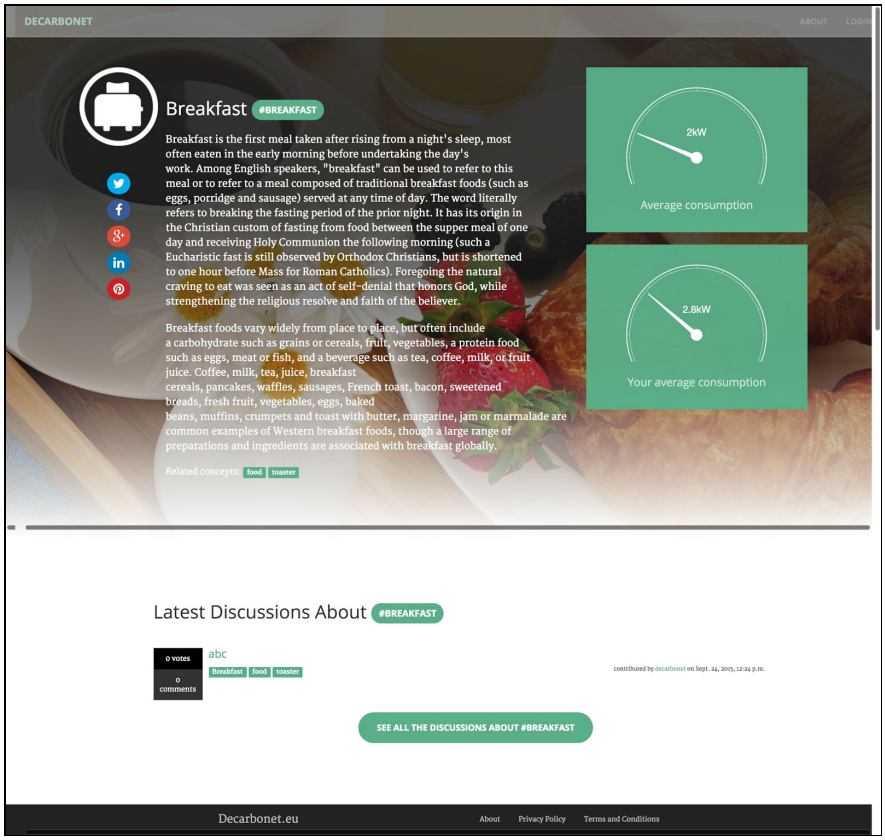


Figure 11 – "Moments of life" page design

The platform application above will be first launched for COP21 (November-December 2015), and kept going through Earth Hour 2016 in March and beyond.

In the next section we describe people and organisations that have been contacted to disseminate the Energy Trial, which later will feed into the Citizen Engagement platform described above.

4 Energy Saving Campaigns

As described in the DoW, WP5 aims to equip 250 households with smart energy meters to enable them to monitor their energy consumption, and to participate in the DecarboNet experiments and applications. First step towards this goal is to locate participants to receive the energy monitoring devices, as discussed in Section 2.1.2. This step has now been fully achieved, and an initial 150 users were identified and supplied with GEO devices. Next step is to attract influential stakeholders, to make them aware of the project's trials and goals, and to secure their support for running such trials, which could help to further disseminate our work, and to attract further users to our platform when its final version is launched, scheduled for late October.

Both environmental-protection related groups and renewable energy communities (or facilitators) have been contacted and requested to disseminate the Energy Trial by

simply forwarding emails or planning further activities with their groups in collaboration with DecarboNet.

Although people related to environmental groups tend to be already concerned with energy conservation, they are also potentially more motivated to engage other people, and to help to disseminate the initiative beyond academic circles.

A number of key people and organisations have been contacted in order to establish partnerships in energy saving campaigns. Some institutions spontaneously contacted our project, expressing their interest in taking part in our Energy Trials. Some of them were focused on peripheral topics, such as permaculture or dissemination of well-being related practices.

The contacts were initiated mostly in early August/September. Some groups demonstrated interest in running activities together with the DecarboNet consortium, which are now under planning. Table 4 lists the contacted organisations and summarises the outcome.

Table 5 - Stakeholders contacted

Institution	Contact	Outcome
National Energy Foundation Independent British charity, established to encourage the more sustainable use and generation of energy.	Director of Households and Communities	Related projects: http://www.yougen.co.uk/blog/ http://www.superhomes.org.uk/ Resume contact in October
Network of Well Being (NOW) Charity that run events, support developing networks and projects to raise awareness about wellbeing.	Community Leader	Interested in running activities together. Contact again in the autumn.
Liverpool council Group or environmental project with communities	Street Scene team	Meeting in Liverpool introducing the project to community centres aiming to organise workshops
South Central Community Transport in Liverpool (http://scctliverpool.com) Community Centre in Liverpool that assists people with mobility impairments.	Community Leader	Introduced by Catherine Morton (council). Interest in organising debate events around energy savings and IT classes related to the platform.
Transition Research Group Transition Network is a charitable organisation to inspire, encourage, connect, support and train communities as they self-organise around the Transition model, creating initiatives that rebuild resilience and reduce CO_2 emissions	Community Leader	Want to invite people related to permaculture to the Energy Trial. Interested in running events together to answer specific research questions.

CleanWeb Non-profit group dedicated to raising the profile of the cleanweb movement in the UK. This movement addresses resource and sustainability challenges with connected information technology	Email to the institution	Help on disseminating the Energy Trial to their followers on Twitter
Cambridge Carbon footprint Local charity that aims to support people to live more sustainably, in particular by reducing their carbon footprint, and organises a number of events throughout the year to do this.	Form on their website	awaiting response
SELCE South East London Community Energy (Greenwich and Lewisham).	Community Leader	Run periodic "cafes" to promote energy saving hints and renewable installations. Help on disseminating the Energy Trial to their Twitter followers. Can potentially run workshops together.
Scottish Communities Climate Action Network A grassroots network of community groups (‘community of communities’) that are taking action on climate change.	Form in their website	Help on disseminating the Energy Trial among contacts
Community Energy Coalition Formed by some of the UK’s most influential institutions and charities such as the Church of England, the Women’s Institute (WI), the National Union of Students (NUS) and the National Trust.	Form in their website	awaiting response
Community Energy England Non-profit organisation, set up to provide a voice for the community energy sector and help create the conditions within which community energy can flourish.	Community Leader	Contact again after summer Introduced the project to other related organisations
Energy Saving Trust British organisation devoted to promoting energy efficiency, energy conservation, and the sustainable use of energy, thereby reducing carbon dioxide emissions and helping to prevent man-made climate change.	Local communities initiatives leader	Contact again after summer
FromConcrete2cookers	Centre for Design Informatics at the	They would have been interested in offering smart

Research project that run a game to help school children understand how carbon emissions were linked to both building fabric and operation.	University of Edinburgh. Meeting at the BHCI and in Edinburgh	plugs to students. It fits the Energy Trial, but their project is about to finish. Could disseminate our trials to their users.
The Energy Community Company that help domestic users reduce their energy bills through personalised advice based upon information that they provide.	Community leader University of Sheffield Email and skype call.	Started a similar website for people sharing hints. Interest in joining forces.
Carbon Neutral University Network (University of Sheffield) http://carbonneutralshef.weebly.com/about.html. Hundreds of supporters throughout the university ranging from academics to undergraduates.	Community leader at the University of Sheffield Email and skype call.	Possibility of running workshops together with students.

Once a preliminary version of the Citizen Engagement Platform is available, these groups will be contacted with an invitation for activities with end-users involving the online platform and the energy devices.

5. Energy consumption data analysis

Beyond promoting energy saving campaigns, the Energy Trial will provide consumption data for the behavioural analysis in the WP4. It is crucial to understand in this first moment how people are actually using the energy monitors, how the consumption data on GEO's EnergyNote looks like, and the possibilities to process it. These insights will determine the baselines for our analysis, will help defining a number of themes for the energy savings campaigns and will also guide further behaviour change analysis.

In the next subsections we describe the profile of the GEO database and present the analysis performed on smart plugs data comparing it to general consumption in the households, and investigating seasonal and periodic variations.

5.1 EnergyNote database and smart plugs

The GEO database consists of records from over **5000** devices, including electricity consumption measurements, solar panel generation, and household heating data. Of interest to the present study are the Solo II and Ensemble devices, which are the models distributed in the Energy Trial. These measure whole house electricity consumption using either a LED reader on the electricity meter or a CT clamp on the mains cable [8,9]. In addition, each display can be associated with up to six optional smart plugs which are used to monitor and control individual appliances [10]. Data from these smart plugs will form the basis of this analysis. Data from all of these devices is stored as total electricity consumption in **15-minute** Epochs, with a resolution of 1Wh per 15 minutes.

There are **810** relevant devices in the database returning whole-house consumption, which are accessible by DecarboNet. Of these, 364 have associated smart plugs, however the majority of these have more than one smart plug associated with them, leading to a total of **1152** smartplugs. Indeed, only 32% of smartplug-associated devices have a single smartplug, while 25% have the maximum **6**.

Smart plugs are labelled by the user, picking from a list of pre-set categories such as Lighting, Kettle, TV etc. The database stores only the current label. This is a possible source of error in the analysis if the smart plug is mislabelled or the appliance being monitored is changed, leading to past usage being attributed to the current category. This scenario may be quite common if the user is actively engaged in investigating their energy consumption, and hence the Citizen Engagement platform need to remind users to relabel their plugs in GEO EnergyNote if they switch their use to another appliance. Refinements of the data analysis in order to detect changes in usage patterns are also desirable, but beyond the scope of the current report.

Although there are 43 possible smart plug labels, 80% of the smart plugs, and 85% of the total consumption, fall into 16 labels. These labels, along with the number of smart plugs and the total consumption for those smart plugs are shown in Table 5.

Table 6 - Smartplug labels and consumption

Label	Count	Total Consumption (kWh)	Average Consumption (kWh)
Unlabelled plug	176	1122.732	6.379
TV	88	2001.116	22.739
Washing machine	83	2155.826	25.973
Fridge	79	5119.829	64.808
Heater	68	3153.086	46.369
Computing eqpt	63	5215.425	82.785
PC	62	5555.680	89.608
Lamp	56	3082.261	55.040
Kettle	41	660.809	16.117
Dishwasher	40	988.289	24.707
Lighting	36	6328.525	175.792
Freezer	35	605.196	17.291

Clothes drier	34	1601.070	47.090
Entertainment	33	1608.641	48.747
Aircon	20	314.659	15.733
Audio eqpt	18	757.676	42.093

Smart plugs provide many opportunities for studying electricity consumption, user behaviour and engagement. They allow total consumption data to be split down to individual appliance level for more targeted analysis and classification of usage patterns. The process of splitting a whole-house consumption signal into individual appliance level is called *disaggregation*. This is an area of active research, both through 'intrusive' methods using monitoring placed in the house, and 'non-intrusive' approaches using machine-learning and algorithmic approaches [13,21]. Smart plugs allow the consumption of devices to be directly monitored as a form of user-controlled intrusive monitoring, but also provide real-time feedback, control and value to the user. Furthermore, non-intrusive disaggregation techniques often rely on having typical consumption patterns for devices which can be used to train algorithms [12]. Smart plugs can provide a library of such data. They also provide direct engagement between the consumer and their energy use. One of the issues which we will examine is whether the presence of smart plugs is correlated with the energy consumption of a household, perhaps acting as a proxy for engagement with energy issues.

5.2 Smart plugs x general consumption

We begin our analysis by examining the mean daily total household consumption. Rejecting devices with average consumptions above 1.5 times the interquartile range as being anomalies or non-domestic properties, we obtain a mean daily consumption of 11kWh with a standard deviation of 5.98kWh, which is in agreement with national statistics [5].

In Figure 11 (left) we plot the percentage of users who fall into average daily consumption bins of 2kWh, separating the data into users with and without smart plugs. While it seems reasonable that owning at least one smartplug is an indicator of greater engagement with energy consumption and therefore a lower usage, this is not borne out by the data. The average consumption is identical in both cases, and the median is actually slightly higher for users with smart plugs. In the absence of other data about the users we do not know what other factors may affect the consumption - for example, if people with smart plugs tend to have larger properties then they may actually be more efficient with their energy use while maintaining the same average due to greater demand. Likewise there is no clear correlation between average consumption and the number of smart plugs associated with a display (Figure 11 (top right)).

Figure 12 (lower right) shows the percentage of total consumption accounted for by smart plugs. Almost all users have less than 20% of their consumption accounted for by smart plugs, and the vast majority less than 10%. Note that this may be because the smart plug has been active for less time than the display and the percentage of consumption accounted for at any given point in time may be higher. A more detailed analysis of the time-series data would be needed to determine this.

So far, we have studied total consumption data aggregated across all devices, smart plug labels and times. We now turn to studying the structure of this time-series data on the scales of monthly and daily variation.

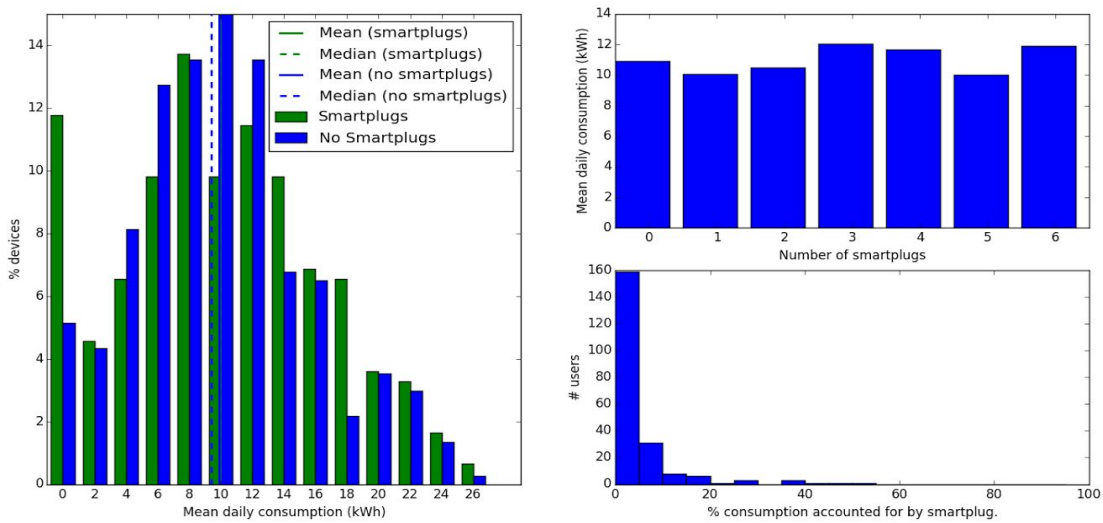


Figure 12 - Smart plugs x general consumption analysis

5.3 Seasonal adjustment

We now examine how consumption varies throughout the year. This seasonal variation is driven primarily by changing daylight hours and temperatures and therefore different categories of electricity usage should be affected differently. Figure 13 (top) shows average daily household consumption for each month of the year. We also plot average daylight hours, mean UK temperature in 2014 [1] and national grid demand data for the same year [6]. The quantities are all rescaled to lie within (-1, 1), to allow comparison of the shape of the curves. We see that national demand follows a combination of daylight hours and temperature. While not exclusively domestic use we believe that the seasonal variation of this data will have the same form. The geo data is not so close a fit to the seasonal factors, most likely due to anomalies in the smaller dataset.

In Figure 13 (bottom) we aggregate the smart plug categories that are likely to be strongly affected by these factors, namely lightning and heating, and plot their variation throughout the year. It is clear that the consumption from these smart plug

categories follows the seasonal trend. We also plot the sum of some categories that are not likely to have seasonal variation (dishwasher, washing machine, TV and computer equipment) and find that their change throughout the year is indeed much less. Finally we plot the sum of the ‘fridge’ and ‘freezer’ categories. These have a smaller change throughout the year but have the opposite seasonal variation. These cooling appliances are on all year round, but have to work harder during the summer months.

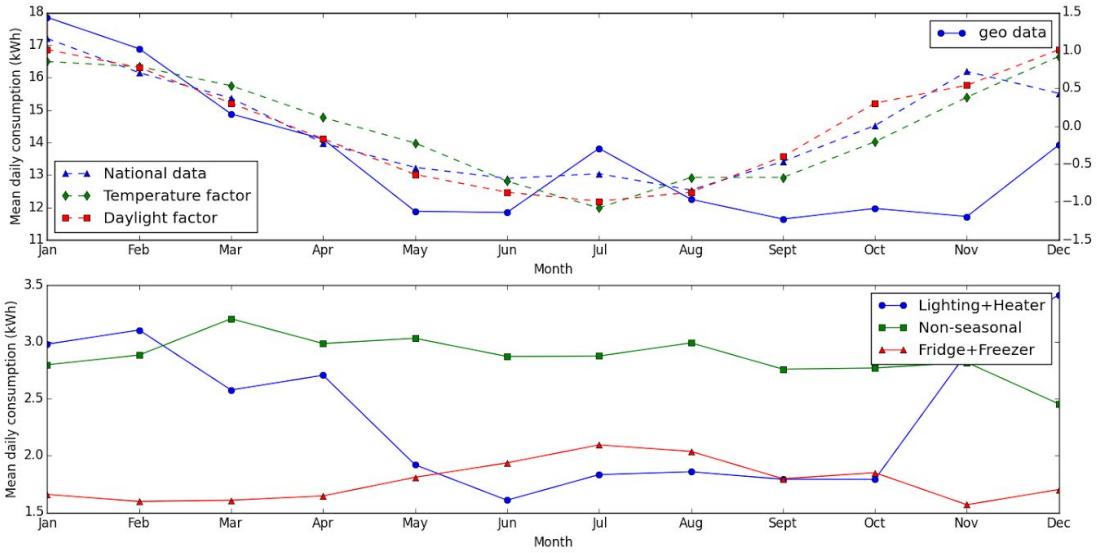


Figure 13 - Seasonal variations in energy consumption

4.4 Typical daily profiles

We now turn our attention to the patterns of usage found within the day. In order that seasonal variation does not confuse the analysis, the data is restricted to be from the month of February 2015. Figure 14 (top) shows the mean total consumption pattern for a day. This is averaged across all devices and days in the month. A number of features are clear - there is a ‘background load’, consumption drops overnight to a minimum at about 05:00, and consumption is peaked around 12:00 and 19:00.

Consumption does not drop to zero at any point, there is always a background load consisting of devices on standby and constantly cycling appliances like fridges and freezers. This background is a considerable proportion of the total consumption, on average 60%, and so identifying its constituents and reducing their contribution is an important step in reducing electricity consumption. From the smart plug data we plot the sum of mean fridge and freezer consumption, this is indeed approximately constant throughout the entire day. It is interesting to note that computing equipment, while showing increased consumption during the day, also has considerable consumption overnight, suggesting that this equipment is frequently left on. Smart plugs left ‘unlabelled’ also show approximately constant usage, but whether this is

because they are attached to constant load devices or it is simply the average of many very different signals is hard to say.

Entertainment, including TV and audio shows a steady increase throughout the day, peaking at 21:30 and dropping off until the early morning, however there is also a considerable constant overnight component. Kettles by comparison have a much more irregular consumption pattern with intermittent consumption overnight, higher usage throughout the day and a large spike centered on 07:45 - breakfast time!

Finally we consider devices that fall into the categories of washing and lighting (washing machine, clothes drier, lighting , lamp). These have virtually no usage between 02:45 and 06:00. Washing appliances then have high usage throughout the day while lighting has clear increased usage between 15:00 and 23:00.

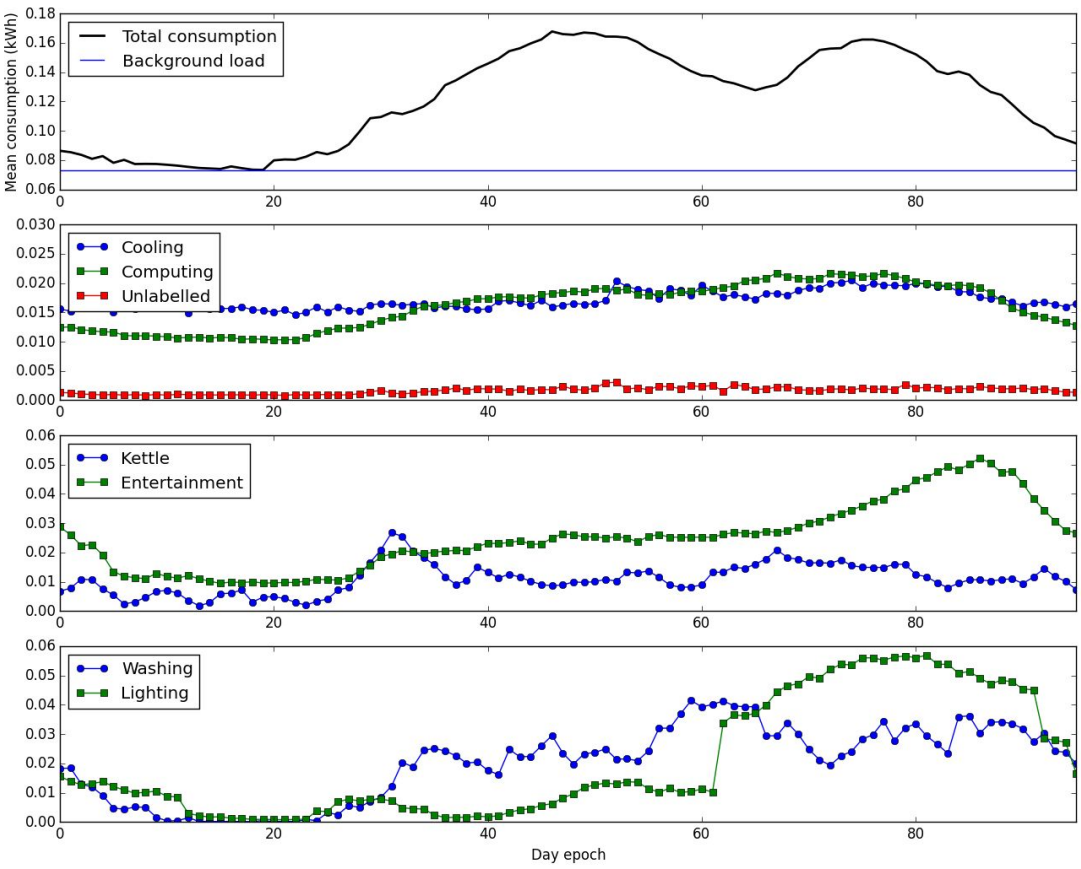


Figure 14 - Daily consumption profiles

This preliminary analysis points to some direction in terms of patterns and constraints that need to be taken into account when investigating smart plug data and how it can be correlated to behaviour change. This shows that we can establish appliance-specific energy consumption averages and patterns (baselines), and have continuous access to energy data from 810 users of GEO devices.

5 Next Steps

The new version of the Citizen Engagement platform will be released late October, in time for the United Nations COP21 event, during which much renewed attention by the media and by the public will be given to climate change. DecarboNet will leverage this opportunity to launch the platform, to build up a user base, to generate content for the platform's forums, and to analyse engagement. Based on our experience with running the platform during COP21, we will make all necessary revisions to enhance the platform further for the Earth House 2016 event in March.

We plan to keep the platform available and running for as long as possible, to cover the events of COP21 (Dec 2016), Earth Hour (March 2016), and any subsequent relevant events. For each event, we aim to tune the platform to fit the topic of the events, to increase fitness and relevance.

In late October, when the platform is launched, we will send invitations to our user base to use the platform, starting with the 150 users recruited for the trials (Section 2.1.2), and the 810 GEO customers we are engaging with our work and analysis (Section 4).

6 Conclusion

The activities and studies reported here are mostly related to preparing the scenario for the Energy Trial. Setting up user groups and distributing monitors, developing the online tool, contacting stakeholders, and understanding consumption data from smart plugs, are necessary conditions to have this user-centred study running.

Studies of this nature require a balance between technology and human aspects. Technology must be accessible, adequate and leads to a good experience of use. But beyond that, it is strategic to identify people and existing groups that perceive the value of the initiative and feel motivated to spread it to their friends and communities.

Preliminary evaluations of the Citizen Engagement Platform, though, suggested the need to review the design to promote interactivity and engagement by the public. The new version intends to evidence the content-generation feature and expand the possibilities to trigger discussions. Widening the focus to "moments of life" and the energy/appliances necessary to perform these things like having breakfast, watching movies with the family, etc., may facilitate the identification of topics of interest by the users.

This new approach to design also needs to be evaluated with users. Workshops in collaboration with stakeholders will provide some initial themes and energy saving recommendations to populate the platform in the initial stages.

In this deliverable, we showed that our energy trials have attracted over 380 potential users, from which 150 were selected and supplied with GEO energy monitors.

Another 100 users will be selected in year three of the project. Additionally, we have access to 810 users of these devices, which we are using to establish energy consumption baselines for various popular appliances. The project is now getting ready for two big events; COP21, and Earth Hour, during which the consortium will dedicate much effort to disseminate its work and applications, and to run further engagement and behaviour analysis.

A. List of Figures

B. List of Tables

C. List of Abbreviations

Abbreviation	Explanation
CA	Consortium agreement
DoW	Description of work, i.e. GA - Annex I
CEP	Citizen Engagement Platform
EC	European commission
GA	Grant agreement
IP	Intellectual property
IPR	Intellectual property rights
PC	Project coordinator
PMB	Project management board
SC	Scientific Coordinator
PO	Project officer
PSB	Project steering board
DM	Data Manager
AB	Advisory board
WP	Work package

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