EC Project 610829

A Decarbonisation Platform for Citizen Empowerment and Translating Collective Awareness into Behavioural Change

D1.1.1: Decarbonisation Methodology v1.0

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Executive Summary

Generating a well-informed methodology for DecarboNet requires a good understanding of the state of the art in intervention strategies, as well as how a combination of such interventions could be deployed and what impact they achieve.

Multiple intervention strategies have been studied in the literature that aim to trigger behaviour change in terms of energy consumption. These interventions range from common feedback techniques, such as energy bills, advertising campaigns, and in-home displays, to more innovative methodologies that exploit collaboration via social networking sites. The effectiveness of these techniques strongly depends on the context (geographical location, climate, development of the region, etc.), as well on the cultural and social aspects of the individuals to whom these strategies are applied. This report provides an initial summary of key interventions for influencing behaviour that have been traditionally studied in the literature.

To better understand how people perceive and react to a suite of interventions towards behaviour change, we executed a user study that consisted of an online survey, two hands-on workshops, and smart energy monitors. The study also evaluated the impact of a tangible device applied as a feedback of engagement, along with a collective knowledge building tool customized for sharing and debating experiences related to energy savings. The aim of the study was to (a) evaluate the role that different technologies play in the awareness/behaviour change process, and (b) understand how people relate to energy in the workplace regarding their perception of consumption, empowerment for changing behaviour, and motivations for being engaged with the energy saving issue.

In this report, we detail the user study above, its outcomes, and the recommendations that can be drawn from it.

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1. Introduction

Excessive or unnecessary energy consumption and use of energy-inefficient technologies, or un-renewable energy, all are known to have support the increase in pollution and climate change.[1]

The challenge is not only to find alternative energy sources or to produce more energy-efficient technologies, but also to raise public awareness on the issues and problems that emerge from their individual consumption and behaviour. A study conducted by Accenture Consultancy Company in 2010 [Accenture, 2010] revealed that there is a significant contradiction between consumer's perceptions and their actual knowledge of energy efficiency. For example, only 42% of the 9,108 users interviewed in that study considered that electricity consumption could negatively impact the environment (despite the fact that traditional fossil fuel-based power generation is a major producer of carbon emissions). It is common for people to not correlate their individual behaviour with global impacts, and thus underestimating their power to influence climate change.

Understanding the mechanisms that govern behaviour with relation to energy consumption, and fostering changes towards conservation, has been the topic of investigation in the domain of social and environmental psychology [Abrahamse, 2005], in computing technology [Fogg, 2003], and in interactive design [Froehlich et al, 2010]. More recently, the potential to disseminate ideas and to engage people via social media has been considered, but how to effectively take advantage of it to raise collective awareness towards climate change is one of the open questions to be addressed by DecarboNet.

This report aims at studying the effectiveness of a selection of intervention strategies (i.e., feedback, educational campaigns, competition, collaboration, etc.) and how theses strategies associated with social media tools can be applied to: (i) raise awareness about energy consumption among individuals and communities and (ii) trigger behaviour change. The report presents an overview of intervention strategies that have been used and studied in the literature to raise awareness and change energy consumption behaviour, focusing on information-perception based initiatives, especially those applicable to real and on-line communities. External factors that influence consumption, such as energy price, smart appliances or energy efficient building are out of the scope of this review.

Details of the different contexts in which these intervention strategies have been successful applied (or not), as well as the lessons learned from them are summarised in order to guide next steps of the development of DecarboNet.

An internal experiment at the Knowledge Media Institute of the Open University, aimed at engaging people with energy awareness is also described, complementing the literature review with local and situated perception of consumption and possibilities for behaviour change.

[1] http://www.epa.gov/climatechange/science/causes.html

2. Towards Behaviour Change: Intervention Strategies and Technologies

This section presents an initial summary of the different studies in the literature that aimed at promoting behaviour change towards energy conservation. This survey will be further extended as part of T1.2 starting in M7.

As a multi-disciplinary topic, the literature review encompasses studies from Psychology, the Human-Computer Interaction (HCI), and Social Science domains, beyond governmental studies or reports provided by utilities.

Our aim is to provide a summary of intervention strategies and tools that have been applied to motivate behaviour change in different sociocultural contexts suitable to the DecarboNet main objectives, considering actions at individual and collective levels.

Some studies were included due to the wide scope of their field of study. In the Social and Environmental Psychology domain, Abrahamse (2005) evaluated 34 interventions according to which factors determine an intervention success or failure. Most of the studies covered by that survey were before the era of digital and interactive feedback devices. Although the studies do not provide sufficient detail of what information has been presented and how, their findings could point to directions for designing new intervention methods and strategies.

Froehlich et al (2012) and Pierce and Paulos (2012) present a panorama of studies related to energy consumption from the Human Computing Interaction (HCI) perspective. Paulos (2012) identifies gaps that are to be addressed by DecarboNet: the vast majority of previous works were focused on the behaviour of individuals, irrespective of the recognised influence of external forces on that behaviour, and the dynamics of social change. That study also highlights that social groups have not been properly engaged, and neither public policy nor legislations were properly considered as part of those research scenarios. This literature review brings to light a number of new approaches to design eco-feedback or to engage people, such as creating artworks or proposing family games, for instance, but very few studies quantify results in terms of savings or behaviour change. Those studies that present a measurable evaluation of the strategies will be described in the following sections.

2.1. Intervention Strategies

Multiple intervention strategies have been investigated in the literature that aim to raise awareness and trigger behaviour change in terms of energy consumption. How motivating are the strategies is a relevant aspect to be considered, since motivation is a force that drives human behaviour. Abrahamse (2005), followed by Froehlich (2010), evaluated a set of possible strategies as motivational techniques:

- **Information:** The lack of information about how to effectively change behaviour is the main gap for awareness. The way the information is presented (whether it is easy to understand, to be remembered, attractive, and presented at the right place and time) is also important for information being considered a motivation technique. Advertisement campaigns (convincing people to adopt a behaviour) and Educational campaigns by teaching about cause-consequences regarding energy consumption are also forms of providing information.
- **Public commitment:** a public pledge or promise to change behaviour usually associated with specific target of reduction. The type of commitment a person

makes, the person or group to whom the commitment is made are factors that may impact behaviour.

- **Feedback**: Refers to providing information about consumption. For Froehlich (2012), effective feedback interfaces should present different levels of information (e.g., immediate feedback, consumption over time periods and the possibility to navigate through aggregated periods, etc.). Feedback alone or in combination with other factors (specially advice) is the most promising single intervention type, with almost all projects that involved direct feedback producing savings of 5% or more [EEA, 2013]. Feedback comes in multiple shapes and flavours in the literature including: (i) energy bills, which are made more informative by adding charts about average consumption and other relevant measures, (ii) smart meters, (iii) in-home displays, (iv), Web, mobile for interactive TV applications, etc.
- **Social feedback (or comparison)**: Social Feedback is provided as a comparative of energy consumption across users and as a dialog or discussion among individuals about their energy consumption needs and habits. We include in this category immediate feedback as well as over time feedback. This intervention strategy has been widely applied in the last few years via social media applications such as Welectricity[2] or Opower.[3] These tools allow users to input the description of their house and their appliances and to compare their consumption with other users. They also stimulate discussions among users and provide advices and plans to reduce energy.
- **Establishing Goals**: Goals established by the user or by third parties (the utilities, for instance). Combined with feedback, can be considered as a motivational technique. A more challenging goal was evaluated as more effective [Becker, 1976]. However, an ideal threshold must be found to keep a saving goal feasible.
- **Competition**: The effectiveness of this strategy is controversial, with some positive, and not so evident results in terms of behavioural change, despite the interest of participants in the competition itself [Johnson & Xu, 2012] [Froehlich, 2012]. We argue that the competition interest may be influenced by cultural context. Social networks are promising environments for stimulating competition.
- **Collaboration**: Collaborative strategies are alternatives to competition. Collaboration aims at aggregating efforts to reach a bigger achievement. Competition and collaboration can be applied together in different levels, such as teams collaborating internally and competing against each other. Another type of collaboration is *pledges*, which brings together a set of individuals to act individually toward a common goal, but their actions together forms a significant contribution to reaching that goal.
- **Rewards**: Are a type of extrinsic motivation that usually promotes a short-term behaviour change. E.g., money rewards. Examples of rewards are saving in energy bills or competitions to win prices such as the San Diego Energy Challenge.[4]

[2] http://welectricity.com/

[3] http://opower.com/

[4] https://www.sdenergychallenge.com/

- **Incentives:** An effective strategy even when prizes or concrete rewards such as money are not involved. Acknowledgements of positive behaviour in the design may already promote the behaviour.
- **Personalisation:** We include in this category a mixture of feedback and personalised education about the user's consumption and how to improve it. Personalisation strategies towards energy consumption are less common in the literature compared to other strategies. Current studies do generally provide very generic feedback that is not necessarily oriented to the necessities of a particular individual. Some works have attempted to narrow the scope of their feedback or recommendations to particular households based on studies of the neighbouring houses (e.g. Opower, 2013). However, even houses may have the same characteristics, not all houses are inhabited by the same number of individuals, and not all these individuals have the same type of energy needs (some may spend more time at home during the day, others during the night, some may have appliances that most households do not have, etc.) Personalisation strategies are focused on studying the consumption of individual users and households and providing them with tailored recommendations that fit their own energy patterns. Opower is an example of power supply that use this type of intervention.

In Table 1, main examples from the relevant literature are summarized in order to provide an overview of the state of the art. Considering that studies frequently combine interventions, it is not possible to establish what the contributions were of each intervention separately. The context of the study (type of tool or environment in which it was applied), and also the target audience are important to be considered when analysing the possibility to reproduce results.

Table 1: Selection of commong intervention strategies and tools

Work	Intervention strategy	Context	Target-audience	Duration	Results
[Welectricity, 2013]	Feedback Social Feedback	Online tool that allows the comparison with peers and advice dialogues with others			- No studies on the effect of this tool
[Opower, 2013]	Feeback Social Feedback Collaboration Competition Personalisation	Online tool that allows comparisons with other households, competitions, team challenges and			- No studies on the effect of this tool

		discussions. It informs the user via web and mobile alerts.			
[Foster et al., 2010]	Feedback Social Feedback	Facebook Mobile app applied in eight trial homes			A significant reduction on energy consumption is achieved by allowing users to compare with their peers
[Petkov et al., 2011]	Feedback Social Feedback	Mobile app that allows the visualisation of data from the user and her peers			It is difficult to compare information because of household differences Users prefer to compare their data against users they know (even if the households present significant differences) Some users were concerned about the usage of Facebook for privacy issues
[Schwartz et al, 2013]	Feedback	Home Energy Management System (HEMS) composed by mobile and TV apps.	7 households in a living lab	13 months	They analysed what and how people learned about energy consumption by means of feedback. Participants learned about: appliance level consumption (also in stand-by); typical consumption level by time of day, always-on consumption in the evening; price of Kilowatt-hour, details about their energy contract.
[Kelsey &	Feedback	Ethnographic	6	8	Although the

Gonzalez, 2009]		study for evaluating commercial in-home displays	families in the UK	weeks	commercial campaigns of meters emphasize the environmental benefit of behaviour change, people adopt the meter for financial reasons. The interest in using the technology decreases over time. It lasted around 2 weeks only.
[Becker, 1978]	Goal-setting Feedback	This study split the participants into two groups, the first setting a difficult goal to reduce consumption (20%) and the second an easy goal (2%) for several weeks. Consumption feedback was provided 3 times a week for half part of the participants within the groups.	80 families in the US	'Several weeks'	The group with the difficult goal conserved the most (15.1%) compared to the control group. The result was seen as a joint effect of feedback and goal setting.
[Siero et al, 1996]	Comparison (competition) Goal-setting Feedback	Two groups of employees participated in a consumption reduction campaign. A group of 50 people received comparative information, while 135	Employees of two units of a metallurgical company in the Netherlands	20 weeks	Comparison created a competitive orientation that improved their performance on saving. The behaviour persisted even half a year after the experiment.

		people received only feedback.			
[Vande Moere et al, 2011]	Comparison (competition)	Public displays were placed in a set of house's façade.	12 houses in Sydney, Australia	7 weeks	Households that received the public display decreased their energy usage on average by 2.5% per week (the control groups decreased 1.0% and 0.5%). The public display further led to a more sustained conservation behaviour compared to only having access to private feedback. The effect of the competitive neighbourhood ranking as being ideal for initiating behaviour change.
[Brewer et al, 2011] [Johnson & Xu, 2012]	Competition Feedback	By using on-line games, students compete to win prizes, and in the process, learn about their current behaviours and their impact on resources such as energy and water.	1000 students living in a residence hall in Hawaii	3 weeks	The study led to reductions of up to 16%. However, this number is not accurate due to baseline assumptions, according to the authors. They also argue that the short time-span of the competitions may encourage the development of unsustainable energy consumption practices for the competition (unplugging vending machines, camping outside, switching on lights in competing dorms etc.) instead of effective behaviour

					change.

2.2. Designing and Evaluating Intervention Strategies

Abrahamse (2005) findings include a guideline to design and evaluate interventions:

- To evaluate the effectiveness of an intervention, it is necessary to consider both behaviour change and reduction of energy use (some works reported energy-saving behaviour but not reduction).
- Combined interventions work better.
- Effectiveness of interventions and possible determinants of behaviour should be examined together. I.e.: a campaign may fail if the group is already familiar with the information provided.
- Feedback is an effective strategy. More frequent the feedback is given, more effective it is.
- Different effects for high and low consumers might be expected. Low consumers may increase their consumption instead of reducing when they realise it is lower, for instance.
- Experiments with small groups tend to concentrate on highly motivated people, so the results cannot be easily generalized.
- Little is known about the long-term effects of interventions. It is unclear whether behavioural changes were maintained and whether new energy saving habits were formed, or whether energy usage returned to the baseline.
- Self-reported behaviour tends to be influenced by social desirability. In other words, people usually report the expected behaviour instead of the real one.
- Rewards have a positive effect on energy savings, but the effect is rather short-lived.
- Commitment and goal-setting are successful specially when combined with other interventions.
- Tailoring (or personalisation) leads to energy savings.
- To design effective interventions:
    - Identify behaviours that significantly contribute to environmental problems
    - Examining factors that make the sustainable behaviours patterns (un)attractive, such as motivational factors (e.g. attitudes), opportunities, and perceived abilities.
    - Interventions must address possible barriers to behavioural change

3. User Study

Initiating reflections about energy consumption in people's daily routines either in domestic or work environment is a challenge, considering that energy consumption is rather "invisible" and behaviour is usually guided by habits and by the environment.

Exploring the energy consumption topic by sharing experiences within a social group and then building awareness collectively may be a promising way to promote behaviour change towards conservation. That is the scenario proposed by this study case that relies on an online debate tool for raising collective awareness in a working environment.

However, introducing a new tool in which people can share knowledge and learn from it alongside other daily obligations is also a challenge that requires a certain level of motivation from the participants to adopt the tool. Thus, the study case evaluated motivational strategies to engage people with an Energy Awareness initiative in the Knowledge Media Institute (KMi) of the Open University.

The study collected participants' perception about energy consumption and possibilities for changing behaviour, evaluated the interaction with the debate tool and the adoption of consumption feedback devices, and also brought into discussion the effectiveness of collaboration and competition as motivational strategies among this social group. The study addresses energy awareness in the workplace, where people usually bring different experiences with energy consumption, and where the individuals' perception, control and autonomy to act are rather different. We argue that exploring the topic of energy consumption by sharing experiences within a social group, and then building awareness collectively, may be a promising way to fill the gap of information towards behaviour change.

Three different technologies were then applied in an experimental setting of an energy awareness initiative in the lab:

1) A social tool for sharing knowledge and debating about perceptions and experiences;
2) Smart monitor devices for learning about individual consumption;
3) The Energy Tree, a tangible device used as a feedback of contributions to the social tool to motivate engagement.

The objectives of the study were:

- To evaluate the role different technologies may play in the awareness/behaviour change process.
- To understand how people relate to energy in the workplace regarding their perception of consumption, empowerment for changing behaviour, and motivations for being engaged with the energy saving issue.

In this report we present results of a qualitative analysis of the content generated by participants on the online debate in order to characterise the interest for specific information, and we rely on self-assessment and interviews to evaluate how different technologies contributed to engage people with the energy issue in the workplace environment.

Next sessions describe the study, its results and conclusions.

3.1. Methodology

The planning for this activity relied on the potential of peer-to-peer learning, dialogue and argumentation to build contextualised knowledge about energy consumption and possibilities to change behaviour. The Evidence Hub, an online debate tool (De Liddo & Buckingham Shum, 2013), was then applied to raise awareness collectively as a first step towards fostering longer-term behaviour change.

Users of the Evidence Hub can create **issues** and propose **ideas** to overcome those issues. Both issues and ideas can be supported or challenged by **arguments**, promoted by **votes** for and demoted by votes against. Users can also add facts or **web resources** to enrich the debate. In the Figure 1 the connection between ideas, issues and facts is represented as a knowledge tree.

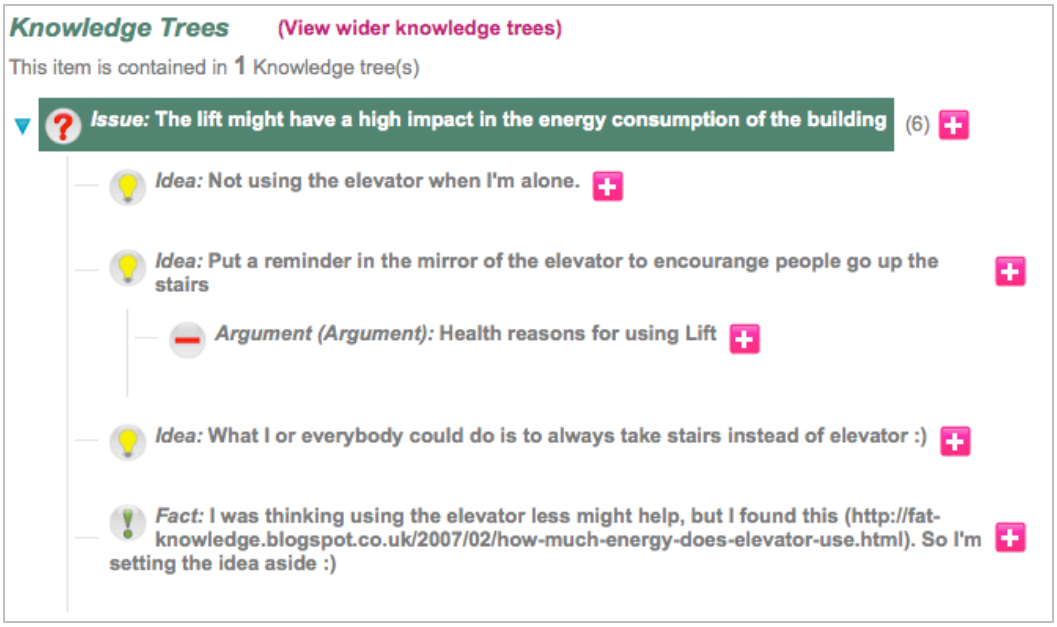
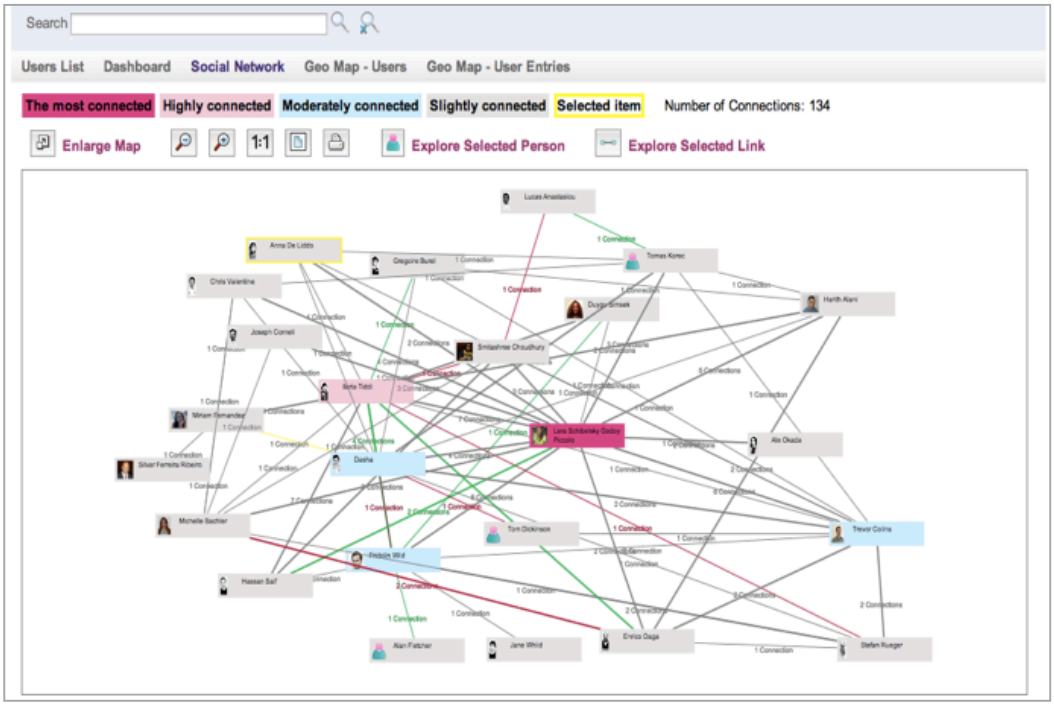


Figure 1 - The Evidence Hub Knowledge Tree

Ideas, issues, facts, arguments are all connected by themes, or by tags. Six themes were setup to shape the online discussion: 1) Behaviour Change; 2) Consuming Energy, mostly issues about how energy has been used and eventually wasted; 3) Environmental Impact; 4) Good Practices, a theme that emerged for sharing the good behaviour that people already had; 5) Institutional Actions, identifying those institutional constraints, therefore out of individual control; and 6) The Tree – a space for ideas of how to apply the tangible device for the experiment.

As illustrated in Figure 2, interactive maps of connected ideas and people strength the social aspect of the tool.

Figure 2 – Map of users connection



We then produced The Energy Tree (**Error! Reference source not found.**) and connected it to the Evidence Hub database to provide a public visual feedback of new contributions. The tree consists of 7 branches of led-lights that get illuminated independently. The way in which the tree lights represents achievements of collective actions. Initially conceived to represent collective savings for a period of time (Piccolo et al, 2013), it was applied as a feedback of engagement to reflect contributions to the debate tool. The assumption was that the presence of the Tree motivates engagement with the online discussion.

Figure 3 The Energy Tree

In addition the debate tools and the energy tree, smart energy monitors were offered to participants as a tool to overcome the lack of information regarding how much energy they are consuming.

Volunteers in our experiment received a kit provided by GEO – the Ensemble Colour Kit,[5] composed by a clip-on CT sensor to get overall consumption, an In-Home Display, a set of smart plugs (Figure 4), and a Web device to make the consumption data available online.

Figure 4 − The Ensemble kit by GEO

Connected to in-home displays, the smart plugs can provide feedback on specific appliances, indicating to what extent they affect the general consumption in the office or house. It is well know in literature the potential of feedback to promote savings from 5 to 15% (Darby, 2006). They are effective on increasing householders' knowledge of their consumptions, but the devices do not necessarily motivate users to reduce their levels of consumption (Hargreaves et al, 2013).

3.2. Experimental Setting

The study took place in October and November of 2013 and was composed of four steps:

1) Online survey
2) Two workshops on the debate tool
3) Smart monitors trial and online debate
4) Sample interview

Step 1 – Online survey

Aimed at collecting initial perceptions about how energy has been consumed in the lab and preliminary ideas for behaviour change.

The online survey was composed by 3 topics: ideas to save energy in the workplace, ideas for personal behaviour change, and problems related to the building or to the institution, splitting individual responsibilities from installation issues or working practices.

Participation was opened to everyone in the department by means of an online form with three simple questions. The results of the online survey were then used to pre-seed the Evidence Hub with meaningful content, thus providing a useful starting point for the online debate.

Step 2 – Workshops

[5] http://www.greenenergyoptions.co.uk/products-and-services/products/ensemble-colour/

Two workshops (WS1 and WS2) were organized to promote the online debate by gathering volunteers to use the Evidence Hub.

The two workshops had the same dynamic, except by the presence of the Energy Tree in WS2, making it possible to compare results and infer about effects of the Energy Tree on engagement.

Each workshop lasted for 2 hours and was run in a meeting room. The Energy Tree was centrally located as a feedback mechanism during WS2 (Figure 5) by reflecting the number of new submitted contributions to the debate tool, as illustrated by Figure 5.

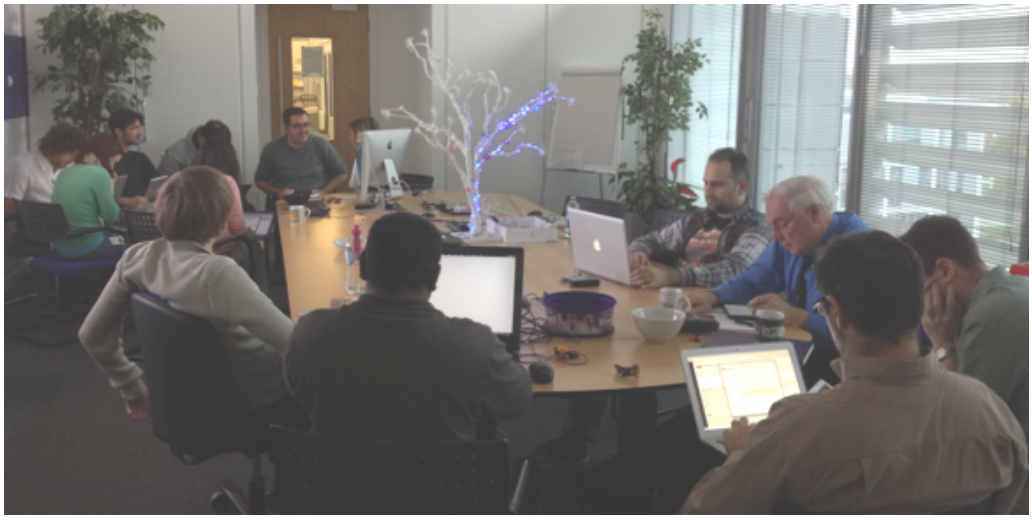


Figure 5 − WS2 with the Energy Tree in the centre of the room

Participants were asked to create, promote or demote Facts, Arguments, Issues, and Ideas online. Half of attendees started promoting or demoting Facts related to Consuming Energy, prioritized them by voting and discussed Issues. The other group created new ideas and voted for Ideas for Behaviour Change, and then provided *for* and *against* arguments for the ideas. After 20 minutes, they swapped roles. The groups engaged in some face-to-face discussions, but most of the activities were done online, on the debate tool.

The content generated in the WS1 was not visible for the participants of the WS2 to avoid influence. It is expected that the Energy Tree motivate a higher number of contributions to the debate tool in WS2.

Step 3 – Smart monitors trial and online debate

Volunteers of both workshops were asked to install the smart monitors at home or in the office for learning about their consumption, and sharing their findings in the debate tool during the following 10 days.

During that time, the Energy Tree was placed in a social area of the department as a feedback of engagement. Every 60 new contributions to the tool (new issues, ideas, arguments, facts, resources or votes) turned on a new branch of the tree. Results of each group were identified and kept alternating from time to time.

Step 4 – Sample interview

To understand what motivated participation, perceptions, as well as the overall experience towards this study, a sample of participants, including the top and bottom contributors, were interviewed about their motivations, perception of the tree and the smart monitor as well as their overall experience with this study.

3.3. Study Results

3.3.1. Participation and contributions

The four steps of the study involved a total of 33 participants, most of them researchers or PhD students not associated with DecarboNet.

A total of 19 people filled out the online survey (step 1). As already mentioned, the answers to the survey were added to the debate tool as the initial input for both workshops. The workshops attracted 24 people (12 each), including 10 of those who answered the online survey. Five people in each session volunteered for the smart monitor trial.

The online discussion started with the workshops (step 2) and continued for the smart monitor trial (step 3), spontaneously attracting also people who did not participate in previous activities.

As summarised in Table 2, Group 1 from WS1 had a lower number of contributions in the workshop compared to Group 2 in the WS2, which had the tree device. But the score inverted in the following week when both groups had the tree as a feedback in the public space. These numbers suggest that the Energy Tree had a positive impact on participation when it was available and visible for the groups. Of course there could have been other factors influencing this behaviour, such as the novelty of the tree concept, and the bias towards gadgets and technologies amongst computer science researchers, etc. Further assessments will be needed to better understand the impact of such variables on behaviour.

Table 2 − Number of contributions to the debate tool

Contributions	Group 1	Group 2
In the workshop	348	542
After the workshop	247	78
Total of contributions	595	620

Group 1 created a total of 92 ideas towards reducing energy consumption, for 58 issues, and voted 430 times. Group 2, instead, generated out 84 ideas for 46 issues and gave 331 votes. The chart below (Figure 6) presents the distribution of types of contribution within the groups. These distributions can be considered adequate for the debate balance, such as the higher number of ideas than issues, as well as the expected high number of votes, which reflects that users accessed other people's contributions and expressed their opinion.

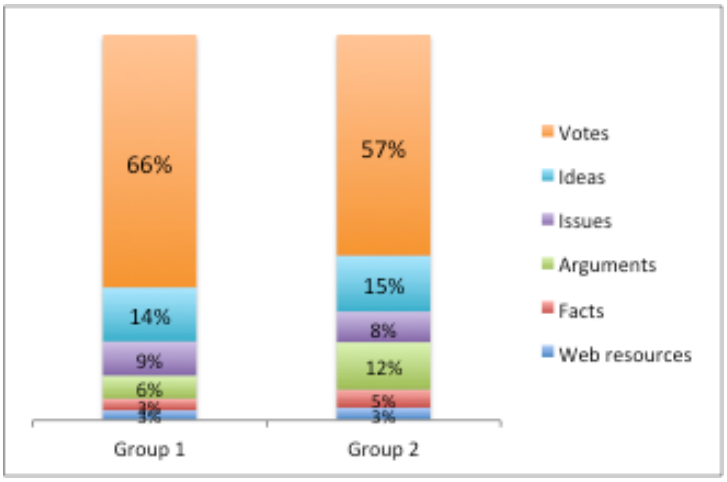


Figure 6 − Types of contributions within the groups

Regarding the content generated, the five most cited appliances/devices were: Lights (26%), Computers (17%), Kettles (8%), PC monitors (7%) and Printer (7%). These demonstrate the appliances that the users believe they can use more efficiently to save energy.

Contributions to the online debate needed to be annotated by the user with one or more of the following six themes: Behaviour Change, Consuming Energy, Institutional Actions, Environmental Actions, Good Practices, and The Tree. Discussions about possible Behaviour Change engaged users more than the other themes, representing 41% of issues, ideas, arguments, facts and votes. 30% discussed how the energy is being consumed. Institutional actions were 21%. Good practices and discussions about the study were a few, 6% together, and only 2% discussed Environmental Impact, as illustrated as follows in Figure 7.

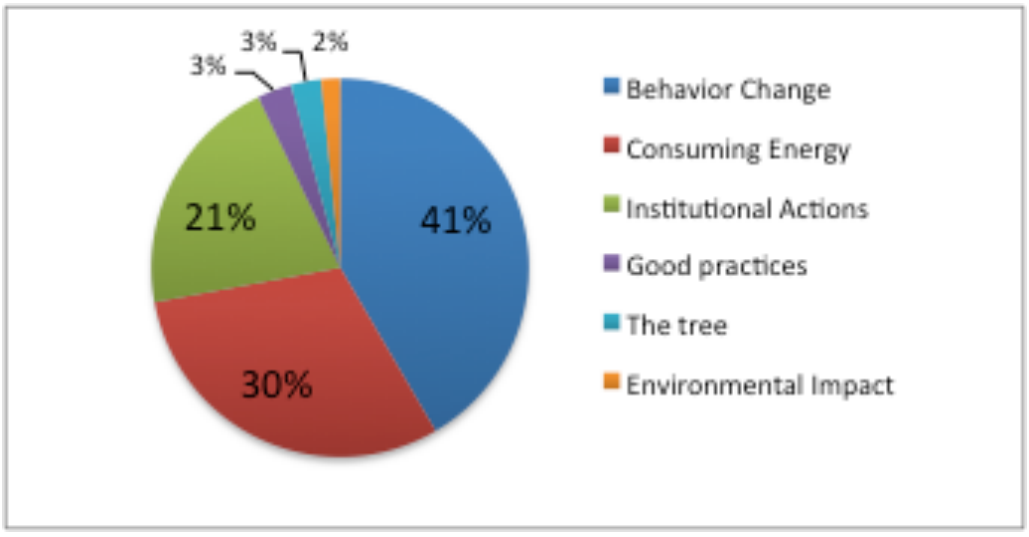


Figure 7 – Distribution of contributions' themes

Volunteers monitored consumption during step 3 and often reported difficulties in installing the smart monitoring devices at the office. The issues were mostly related to network security constraints that prevented them from setting up the Web

monitoring devices, and to clipping the sensor close to the main meter, which is inaccessible to them. To this end, most participants took the energy monitoring kit to their homes instead. Nevertheless, only 2% of the contributions within the debate tool referred to data collected from the monitoring devices or shared experiences about the usage/installation. This is partly due to the setup of this study, which did not mandate the use of those devices, to demonstrate that energy debates and ideas for changing behaviour are not necessarily tied to the usage of smart meters, although they could be enriched and informed by such devices.

When asked to score from 1-5 how they liked the equipment, 83% of respondents of the sample survey scored with the maximum value (5), and 17% scored as 3.

Participants' motivation and the impact of the Energy Tree were also collected by means of the sample interview (step 4) with 10 participants, 4 people from Group 1, and 6 from Group 2, both including those who most contributed and who did not contribute at all after the workshop.

When asked to choose up to tree reasons to be engaged in this study, the Energy Tree came second behind the interest in the energy topic: 1) To learn about energy (33%); 2) To see the tree functioning (26%); 3) Interest in the smart monitor devices (19%); 4) The social aspect of the activity (7%); and Others (4%).

Participants were also asked to score from 1 to 5 the level of attention they spent on the tree during WS2 and during the time it was installed in the public area. The public space gathered more attention, as illustrated by the chart in Figure 8 . The average score of attention in the workshop was 3.5, while in the public space was 3.9.

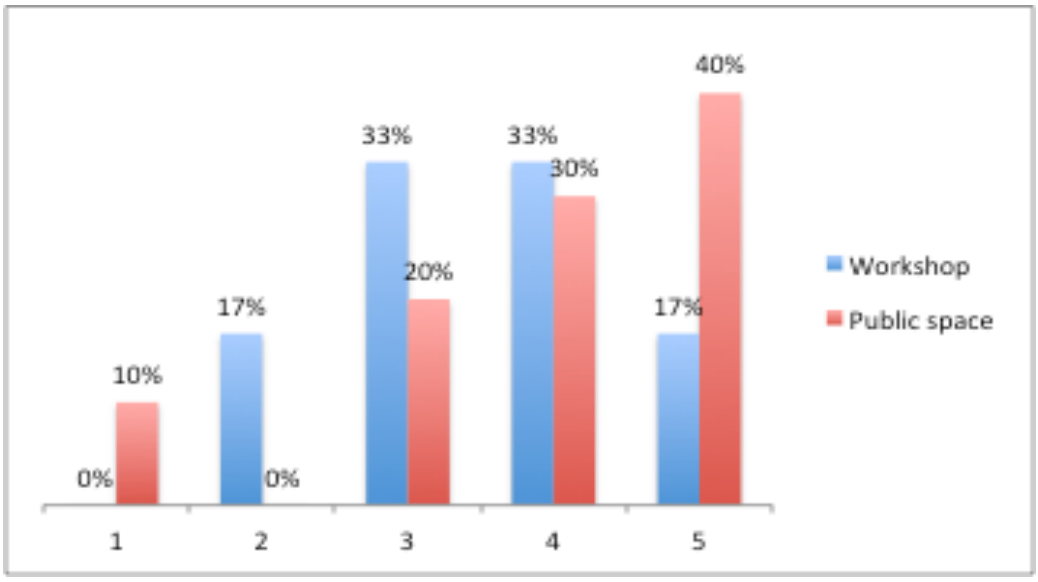


Figure 8 – Score of level of attention to the tree

3.3.2. Influence smart monitoring devices

The knowledge acquired by means of smart monitors constitutes an important source to guide perception and choice. In line with the role of smart monitors identified by Schwartz et al (2014) to promote energy literacy, answers to the interview evidenced how smart monitors were used:

- For learning about the cost of appliance energy consumption: "*I have calculated some basic costs of e.g. a washing cycle, a toast, one year of fridge*", reported a participant.
- For tracking daily energy consumption: "*I am usually monitoring consumption of specific devices over a period of a few days and using the general meter reading to pay attention to the energy intense usage periods during the day*."
- For comparing consumption of appliances: "*I observed consumption while the laundry or pot is running: reasoned that pot even if it runs for a short period of time and such a small electrical device it actually consumes a lot of energy*", and guiding choices: "(…) *it has changed the way we use quite a few things in our house. For example, we don't cook rice using the electric cooker or microwave because it consumes too much of energy. Instead we use a pressure cooker. We also stopped using the kettle to boil water*".
- For understanding cause-effect: "*I was using the smart devices at KMi. I was curious how much energy does my laptop and monitor use on daily basis and also whether the monitor keeps using energy while in standby mode. This was the reason why I now started switching the monitor completely off before going home every day*".
- For mapping consumption in the house: "*creating usage stats for the following items, so that I can then target high usage areas. Monitoring Fridge, Freezers, Dish Washer, Washing machine, Kettle, Two TV's, Home Server, Printers, PC, Lighting*".

Information related to monitoring consumption was not typically discussed in the online debate. Instead, we observed that the discussions about the device installation and the findings obtained by using them happened among colleagues mostly informally, during coffee breaks, lunchtime or around the energy tree installation, for instance. A possible reason is that personal information like "*the old one (fridge) is consuming twice as much as a new one would. Could half my energy costs for the fridge per year down to £25 or so*" was considered of private interest, and not suitable to be shared with colleagues in the working environment.

3.3.3. The debate tool

The number of arguments and votes suggests that the tool was effective in promoting the debate, as the knowledge tree of the discussion about how to motivate people to save energy illustrates in Figure 9 with the issue that "*saving energy is a very boring thingy"*.

Eventhough being suitable and promoted to be a place for sharing domestic experiences regarding energy consumption, the software was perceived as a working tool. Despite of that, people usually expressed themselves like in an informal conversation (the hierarchy seems to not have affected discussion). They did not restrict their answers to possible behaviour change, some wanted to point out pro-conservation behaviour that they already had, suggested things for the current study, and others pointed out Web references, which demonstrates that they have probably investigated the topic before adding a new idea, issue, fact or argument. The online tool also attracted other people in the lab to join the discussion, eventhough they did not participate in the workshops of this study. The ebate tool was rarely accessed to post domestic consumption data.

For being the most simple and direct action, voting represented the majority of contributions, being considered as a relevant way to promote the debate.

Nevertheless, it was unclear how people evaluated the voting action, whether considering it by the relevance or as a sentiment evaluation (good or bad). The fact of informing the amount of annual money spent in the building and comparing it to the number of houses that could be powered is an example. It received 3 promoting votes and 4 votes demoting it.

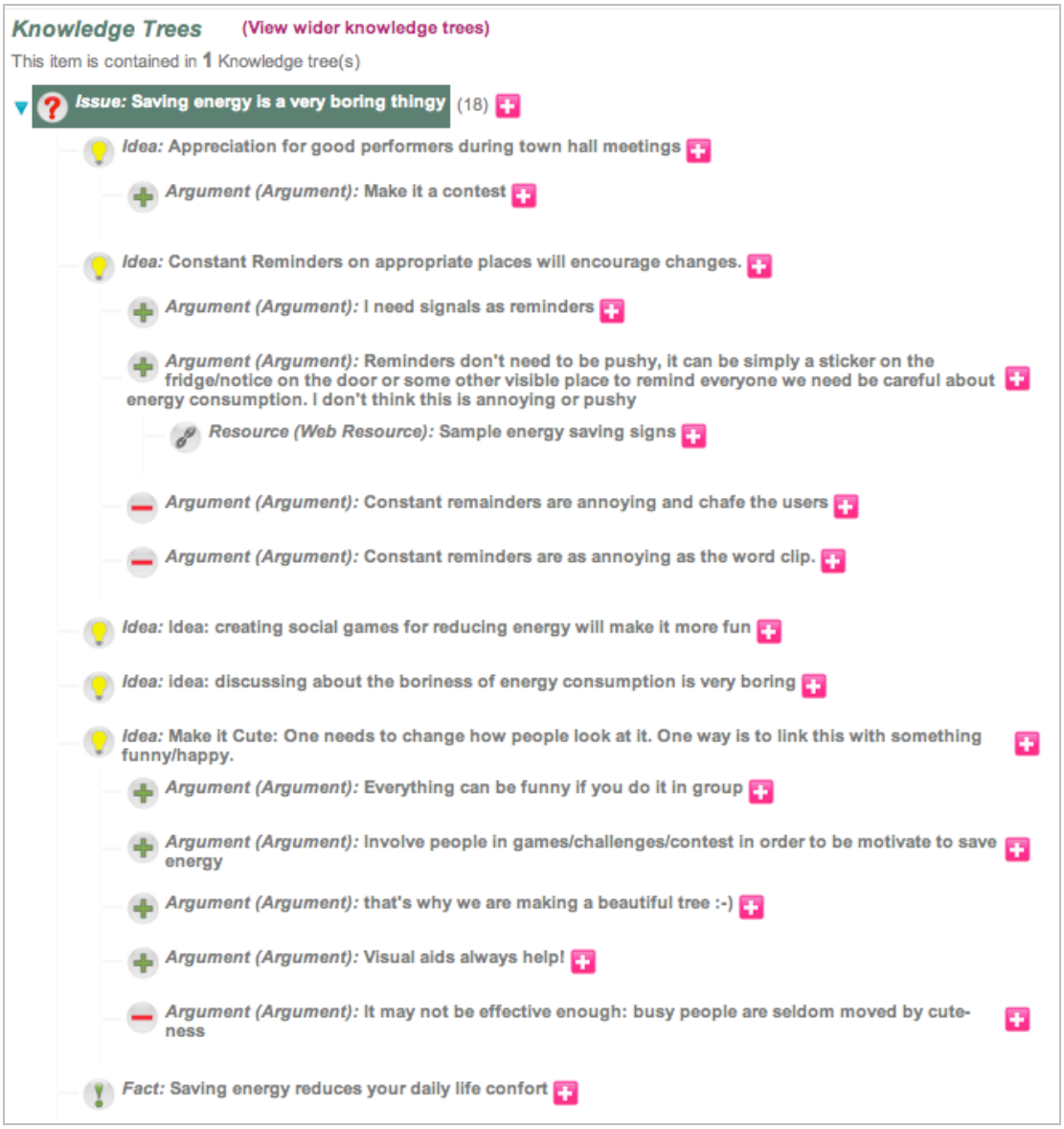


Figure 9 − Knowledge tree generated by an issue

3.4. The Energy Tree

The presence of the tree in WS2 and in the public space seems to have influenced participants' perception and motivation.

The workshop that had the tree produced more contributions, but interestingly, seems to have hampered their motivation in step 3. A participant declared: "*I left the workshop with the feeling of mission accomplished, we lighted the tree on. It did not make sense to me to light the tree once again*".

Considering that during the workshop people spent most of the time working on their laptop to feed the debate tool with their contributions, and not paying as much attention to the tree, when the tree was placed in the public space it became more effective in attracting participants' attention.

When asked about their thoughts when they saw the tree in the public area, participants of Group1 and Group 2 reported different perceptions:

- Group 1: Mostly competition: "*Shamelessly competitive: Is my group doing best?*" and "*is our team ahead?*"; how much progress was done "*I wanted to see all the lights on*"; collectivity: "*some people are saving energy*".

- Group 2: For the group that did not created new posts after the workshop, the tree generated the feeling of guilt. Three people mentioned being guilty, like "*it makes me feel a bit guilty when it is switched off - like I am not fulfilling my responsibilities*", another two people were always comparing to the other group. One participant highlighted the characteristic of the tree of being both decorative and meaningful together.

The Energy Tree definitely worked as a symbol, a reminder of the ongoing activity, as illustrated by this post: "*It looks like thanks to the tree we started switching off the lights during the day".*

The comparison (and consequent competition) between groups, however, caused a guilty feeling for the group that was not doing well.

3.5. Content analysis

By qualitatively analysing contributions of Groups 1 and 2 together, we can further explore and identify the topics that the participants discussed. The analysis took into account some tags initially added by participants to the items in the debate tool. Other tags were added for the analysis. The contributions were then grouped by affinity leading to a set of 18 distinct topics. In Table 3 − Topics of contributions and quantitythe topics are ordered by the number of contributions.

Table 3 − Topics of contributions and quantity

Topics of the contributions and quantity		
1	The working environment (making it comfortable, trade-off between comfort and savings)	40
2	Switching off, turning-off, shutting-down, unplugging, standing-by devices (computers, monitors, desktop, printers, lights,…)	37
3	The automation system efficiency (lightening sensors, heating)	27
4	Working infrastructure (computers, kettle, phones)	27
5	Efficient usage of appliances (battery x power, ideal settings, adjustments)	22
6	Reminders for conservation	19
7	Personal attitude towards saving ("I use to do…")	19
8	Replacing devices (and the analysis of the cost of manufacturing them)	16
9	Motivation strategies (group work, competition, games…)	15

10	Costs of consumption in £ (by monitoring or by means of Web resources)	15
11	Reviewing working practices (printing, coffee breaks, meetings, working time)	15
12	Outcome of the energy awareness initiative (feedback of performance and claims for rewards)	12
13	Instructions for changing behaviour	11
14	Claim for getting more information about consumption (institutionally or personally)	10
15	Forms of presenting consumption feedback (personalization, granularity, etc)	6
16	Reports of appliances consumption (by monitoring them or by means of Web resources)	6
17	Dealing with stakeholders	5
18	CO2 emission	4

Being confortable at work it is an evident claim by participants. How to balance energy savings with eventual impacts to personal comfort is also part of this discussion.

Topics like "*Reminders for conservation*" and "*Instructions for changing behaviour*" highlight the recognized need of having proper information to guide behaviour change. In general, 20% of ideas, issues and arguments together refer to claims for information about individual or institutional consumption, outcomes or suggestions about how to present feedback, reinforcing the lack of information as a gap for awareness. An an evidencte, the issue referring to the lack of information "*People usually have very few information about the impact of their consumption*" was the 2nd most voted.

4. Recommendations for providing information

Grouping the content by general topics points to a direction about what people considered relevant to be discussed. However, this analysis is not enough for providing a broader recommendation in terms of what to inform and how to provide information that may also be suitable to different contexts. To do so, the content produced was then grouped, taking into account three different levels of information:

- **Appliances consumption:** what/how to inform about appliances usage.
- **Collective awareness:** information to be provided to raise awareness collectively, in a social context.

- **Personal values, beliefs, and motivations:** individual expectations to change their behaviour.

4.1. Appliances consumption

- **Quantify in money/kWh/CO_2 the benefits** of small actions. I.e. shutting-down, or unplugging every-day devices, in comparison to stand-by mode.
- **Efficient usage.** Provide instructions about how to configure or adjust appliances to use it efficiently and in an optimized way. Ex: monitor brightness, cooler speed, etc.
- **Inform direct costs of daily actions**. I.e. "*how much do I spend laundering during all the year*" or the cost of using a kettle for making the daily teas. Cost was also the argument against the issue about big monitors consumption: "*the consumption is 19.8 kWh/month, between £2.12 and £3.31 per month depending on the energy supplier*".
- **Inform about the energy spent to produce new devices and hints about when to replace them.** "*The energy required to produce 1 PC is more or less the same as what 3 family members use in 1 year!*", is an example.
- **Providing simple and clear instructions of what to do for each appliance and when**. Such as "*switch off the printer after using it*" or "consider *replacing your fridge when the consumption is higher than…".*

4.2. Collective awareness

- **Publish outcomes.** Provide periodic visual feedback about how much energy and money have been saved by following simple instructions.
- **Assign responsibility for people**, such as for switching off appliances and devices.
- **Publicly recognize good behaviour,** both namely and in general. A suggested way was by promoting achievements, such as using a sign "congratulations for using the stairs! We can save # of CO2 (or £) in a year if # people do the same everyday".
- **Ensure that shared infrastructure in the scenario is energy efficient**, such as kettle, hand dryers, etc.
- **Evidence that saving energy is not a disconnected action from the whole global actions or policies**, and other necessary stakeholders are involved to make it successful in larger scale.

4.3. Personal values, beliefs and motivations

- **Recognition.** The most voted contribution in the debate tool is a fact declaring a good behaviour: "*I always shutdown the computer at night*".
- **Dealing with comfort.** People are worried about loosing comfort due to energy saving "*knowing what the long term benefits are could offset the short term inconvenience*". A fact informing the consumption of big monitors and the negative votes it received is another example. So instead of feeling threatened by consumption information, people must receive instructions to avoid energy wasting, for example, turning off monitors when they are not in use. How motivated a person is determines his/her willing to leave the comfort zone, witch is a subjective variable too.

- **Different motivations.** Some people just want to learn about the topic, or to listen other people's ideas. Not all of them are aiming to change behaviour. But it is important that everybody feel motivated to engage with the awareness initiative in order to instigate such motivation. As a research-working environment, the interest to learn about energy as a research topic was also declared as a motivation for being engaged.
- **Keep personal data private.** The preference for not sharing personal data was evidenced not only by the few who reported consumption data from home, but also by posts like this one: "*access to information about our energy use at a useful (but not too personal) level of granularity*".
- **Make it funny.** A cute and non-intrusive reminder was claimed, as well as initiatives to work in groups. "*Everything can be funny if you do it in group*".
- **Reminders.** They were stated by participants as necessary, but how to present them was deeply discussed: "*People are already bombarded by caution messages everywhere in their daily life ("mind the gap", "fire safety*",...). Such reminders shall be carefully chosen not to be categorized in a person's perspective as " *not so necessary messages*".

The connection between energy consumption and environmental impact was weak or non-apparent in the content analysis. This was evidenced by the very few number of items connected to the theme Environmental Impact. Despite being the main concern of DecarboNet, the connection with climate change and environmental issues was not an attractive perspective for people in this scenario. The fact that *"approximately 48 trees are needed to absorb the CO_2 equivalent to 11 months of using a 27" monitor 6 hr/day",* for instance, did not have any repercussion. This could be due to various reasons, such as not providing evidence or factual information to back this up, message not clear enough or too general, etc. As a general recommendation to further activities, the environmental impact must be constantly reinforced and linked to energy consumption.

5. Conclusion

This deliverable summarised our survey so far of the common intervention strategies studies in the literature for the domain of energy, and their apparent impact on changing people's behaviour. Additionally, we presented a user study to evaluate the role of three technologies to promote energy awareness in a research workplace: a debate tool, smart monitors, and a tangible device to motivate engagement. Our current analysis showed that promoting awareness is not only a matter of providing technical artefacts or information. The artefacts actually need to dialogue with the formal context where current institutional practices are, and also with personal elements, such as motivation to deal with comfort and the existence (or not) or any environmental concern.

The debate tool has demonstrated to be adequate for gathering opinions to build awareness collectively. As a simple action, voting was an effective way to engage people in the discussions. The possibility to easily interact with other people's opinions might be a motivation to engage those who are not willing to change behaviour initially, but are interested in raising their awareness. On the other hand it

was perceived as a working tool, in which private consumption data, which was supposed to be shared, did not appear.

Exchanging experiences and ideas about how to save energy is an important way to raise awareness, but real consumption measurements seem to play a fundamental role to complement this scenario with contextual and personalized information. However, in the social context of a workplace, this information was not suitable for a public discussion according to the results.

The motivational role of the Energy Tree was well noticed, but it may not have been the only factor in promoting participants' motivation. However, its role as an attractive reminder was clear.

The three technical elements complemented each other and together promoted ideas, issues, arguments, and facts that were analysed, pointing out aspects that people are interested to discuss in an energy awareness initiative in the workplace.

Complementary, the topics explored on the online debate were extracted and analysed, pointing to directions where the gap of information is and how people in that context wanted to be informed. This analysis showed that the connection between energy consumption and climate change or environmental impact was weak or almost inexistent, suggesting the need of further work to better promote this connection in new studies.

In the remaining period of DecarboNet, we will expand our study of the literature on behaviour and intervention strategies, and will aim to run a wider, but more focused, user experiment to further investigate the impact of certain strategies on energy consumption behaviour.

A. List of Figures

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C. List of Abbreviations

Abbreviation	Explanation
CA	Consortium agreement
DoW	Decription of work, i.e. GA - Annex I
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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