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# Smiling Earth - Citizens' Awareness on Environmental Sustainability using Energy and Transport Data

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**Abstract.** This paper describes the design and implementation of a mobile app, Smiling Earth, to support citizens to contribute to climate change by being aware of their carbon footprint and making changes in their daily energy consumption and transportation. One of the main aims of this work is to explore the ways in which ICT could help raise awareness and educate citizens about their actions and their consequences on the environment. The Smiling Earth app is designed to visualise data about citizens' activities and to motivate citizens to change their behavior to reduce their CO2 emissions by changing their transportation habits. The app takes a broader perspective of CO2 emissions, bringing together the transport and energy sectors. The design process and a preliminary evaluation of Smiling Earth is presented in the paper. This work has been conducted as a part of the EU DESENT project.

**Keywords:** CO2 emissions, Green transportation, Urban Mobility, Carbon Footprint, Behavior change, Gamification,

## 1 Introduction

Global warming is one of the biggest and most urgent issues facing the world today. Transportation, electricity consumption and domestic heating are responsible for a large part of greenhouse gas emissions, which contribute to climate change. One of the biggest contributors to Carbon Dioxide (CO2) emissions is transportation. Savings can be made with better energy and transportation management transport is the sector where most emissions cuts will be made in the near future [1]. While physical activity such as walking or cycling for short trips are possibilities, many still choose to drive to work to save time and for flexibility [2], or out of habit [3]. The main motivations for the work presented in this paper is to explore the use of ICT to motivate citizens to reduce their carbon footprint by changing their behavior. We believe that this is a relevant step towards taking action to combat climate change and its impacts and for responsible and sustainable societies, in line with the United Nations' Sustainable Development Goals

(SDG). One of the areas in which ICT could contribute towards achieving the SDGs is to help citizens perceive them as goals they will contribute to as a part of their daily lives. Indeed technologies are most effective when they help people to achieve the goals they have already decided upon [4].

The success of smart urban mobility needs integrated solutions about energy, transport, service and governance with the full involvement of multiple stakeholders, such as governments, public and private enterprises and citizens. The European project, DESENT, focuses on providing a smart decision support tool for urban energy and transport, by developing innovative approaches and utilizing cutting-edge technologies using co-creation. The DESENT consortium includes municipalities, universities, research institutes, enterprises and private companies from Austria, The Netherlands and Norway, and tackles the various challenges by implementing innovative solutions in demo cities. One of the focus areas of DESENT is to support smart decision making for policy makers and personalized services for citizens.

The aims of this paper are to describe a gamified pervasive mobile app, Smiling Earth, designed to create awareness about carbon footprints and affect individuals' behavior change towards more sustainable choices and actions in their daily lives. The overall research question addressed is the paper is: Can the combination of energy and transport data and individual energy consumption in terms of CO2 emissions motivate people to manage energy better and reduce CO2 emissions? Smiling Earth, is designed to (i) increase citizens' awareness about their CO2 emissions through visualising data about their daily activities; and (ii) motivate citizens to change their behavior to reduce their CO2 emissions by adopting a healthier lifestyle. Smiling Earth takes a broader perspective of CO2 emissions, bringing together the transport and energy sectors as well as the lifestyle (e.g. transportation modes) of individuals. A few earlier examples of mobile apps that address green transportation and sustainable urban mobility are reported in the literature; *UbiGreen* tracks an individual's transport options, e.g. carpooling and walking, and provides feedback using a metaphor from nature as the "wall paper" for the mobile app [2]. Another app is the MUV which encourages people to adopt sustainable mobility modes livability [5, 6].

The rest of this paper is organised as follows: Section 2 describes the design process; Section 3 describes the Smiling Earth app; Section 4 describes the evaluations and provide an overview of the main results; Section 5 concludes the paper.

## 2 Design Process

The user group for the Smiling Earth are the general citizens and electricity consumers in urban areas. Since the project consortium included energy companies and we had easy access to them, we chose to work closely with them to leverage on their knowledge of their customers. The design and development team also included researchers with engineering, ICT and economics backgrounds. A participatory design approach was followed. Several formative evaluations and design iterations were conducted using sketches and the rapid prototyping tool Proto.io.

Designs to affect behavior change require an understanding of how humans adopt or change behaviors. We have based our work on the Transtheoretical Model of Behaviour Change (TTM), developed in the health sector [7]. TTM posits that behaviour change progresses through six stages of change: Precontemplation, Contemplation, Preparation, Action, Maintenance and Termination. The first stage is to inform users to raise awareness and then to educate and persuade them to contemplate and take action.

## 3 Description of Smiling Earth

The central concepts that influence the design of Smiling Earth are CO2 emissions, health benefits, environmental impact and economic profit. The Graphical User Interface (GUI) for the main page is designed to reflect these concepts and draw the user's attention to the concept of CO2 emissions and how that affect the world we live in; see Fig 1. Metaphors have been used to create emotional attachments to concepts such as the environment; e.g. [8-10]. We have used the earth as a metaphor to show the impact of a high carbon footprint (global warning) which may be caused by the user's actions. The dashboard for the app, shown in Fig 1 (a) and (b), show the daily values of CO2 emissions by an individual, from transportation and domestic heating. The circular indicator informs the user about the current value emissions in kg of CO2. The number indicated in the circle is the daily value. The circular progress bar for each circular indicator shows the user's value relative to the maximum allowed level of emissions; i.e. the target for the user must be less than this maximum amount. The daily goal for the CO2 limit is 4 kg CO2 for the carbon footprint.


**Fig 1 Smiling Earth concept and GUI**

The screen shots in Fig 1 show three possible states (out of five); (a) shows a very happy earth due to low emissions with respect to the maximum level; (b) shows a happy face, but less happy than (a) as the CO2 emissions are reaching close to the maximum; (d) shows a very dismal picture of the earth due to a high level of emission, far above the maximum level. The colour code used in the GUI are blue for values that are related

to housing (such as the household heating and electricity consumption) and green, which is related to transportation, such as walking, cycling or EVs.

Figures, (c) and (d), show estimations of CO2 values, when the user selects a transportation or heating mode. The symbols on the bottom of the screen are "estimation buttons" which are for solar panels, walking, cycling and an electrical vehicle, from left to right. By clicking on the "estimation buttons", the relevant values will be displayed. For example, in Fig 1 (c), the estimated CO2 emission by selecting an electrical vehicle is shown as 0.0kg. On the other hand, the estimation for walking while either sometimes driving a combustion engine vehicle or using conventional heating means could lead to a higher CO2 emission as shown in (d). These values are based on statistical data [11] and analyses conducted by SINTEF Energy and the DESENT partners.

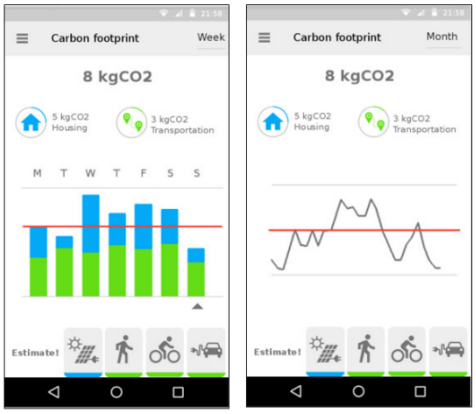


**Fig 2 Smiling Earth - CO2 emission data visualization**

A menu on the top left of the screen enables users to see their CO2 emissions and other values such as calories burnt and money saved, over the previous week, month or year. The visualisation of CO2 emissions for a week and for a month are shown in Fig 2 .The red horizontal line marks the maximum limit; i.e. users are encouraged to keep their total CO2 emissions below that level. The blue and green colour coding is used to indicate the emissions due to household actions or transportation actions; e.g. Fig 2Error! Reference source not found. (a) shows that 5kg of Co2 out of the total of 8, are from household activities. Bar graphs are used to visualise the data for a week while the continuous graph shown in (b) is another visualisation of the data for a longer time period such as a month or a year.

Two approaches are used to calculate the carbon footprint and costs related to the energy consumption. In the first phase of development, users provide a monthly value of their electricity consumption. A typical yearly energy consumption profile is then calibrated to fit this value. The carbon footprint and costs from driving are estimated on user provided data for fuel consumption and a conversion value of 2348 gCO2e/L [12] and the distance travelled captured by the mobile device.

# 4 Evaluation

The focus of the evaluations were the concept and overall design and the GUI. Questionnaires were used to obtain systematic feedback. Screenshots of the design were presented with brief explanations, followed by discussions and a questionnaire, designed to evaluate the general concept, usability, motivations and behaviour change of the users through using Smiling Earth. The main feedback was about the values that were shown on each screen so as to minimize the cognitive load on a user to remember information across the different screens. One concern was the quality of the data that is displayed as this was important for the users to gain trust in the data and the app.

This paper reports the responses to the questionnaire for the specific questions related to the motivation of the user. There were five participants, who were university students. The participants were asked to install Smiling Earth on their mobile devices and use it for 8 days. The questionnaire included a set of statements (42 in total), where the users were asked to agree or disagree, based on a Likert scale: 0: Strongly disagree, 1: Disagree, 2: Neither agree or disagree, 3: Agree and 4: Strongly agree. The set of statements that are relevant for evaluating if the concept of Smiling Earth is understandable and if it can motivate citizens to affect their behaviour are shown in Table 1.

**Table 1.** Statements on Motivation and Concept (the number of the statements in the evaluation questionnaire have been used)

| Questions | Related to Behaviour Change and Concept |
|---|---|
| Q3 | Viewing the data visualized in the app made me want to make some changes to reduce my emissions. |
| Q6 | The app motivated me to change my behavior to a more sustainable one. |
| Q7 | My concern for the environment has increased after using the app. |
| Q15 | I understand clearly the purpose of the app. |
| Q16 | The link between energy, carbon footprint, activity, and expenses is motivating. |
| Q17 | I am more curious about energy and environment after using the app. |
| Q19 | I find the earth metaphor engaging. |

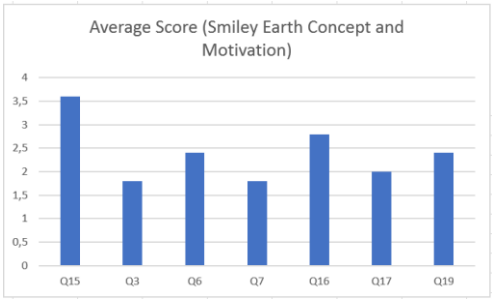


**Fig 3 Smiling Earth Evaluation - Concept and Motivation**

The responses to the statements in Table 1 are shown in Fig 3. The responses to Q15: "I understand clearly the purpose of the app" has a score >3.5 (between agree and strongly agree) and there was general agreement that the earth metaphor teaches the impact of a high carbon footprint. The users also agreed to the statement about the overall concept, Q16, (the link between energy, carbon footprint, activity and expenses is motivating). These are encouraging results, considering that several participants from the formative evaluations had found the concept complicated and difficult to understand. Furthermore, the threshold of relating energy consumption data to one's own carbon footprint and contribution to the CO2 emissions was high. The users neither agreed or disagreed to the statement that Smiling Earth raised curiosity about energy and environment, Q17.

The responses to Q3 and Q7 suggest that the users' concerns for the environment were not increased after using Smiling Earth. Through the discussions after the questionnaires, it appears that they were aware of the climate problem and want to do something about it and they wanted to engage others. The discussions also indicated that the users' knowledge about CO2 emissions were improved and the awareness among them about the impacts of their everyday activities on the environment was increased. The responses to Q6 show that the users neither agreed nor agreed to the statement that Smiling Earth motivated them to change their behavior. This is perhaps related to the responses to Q3 and Q7 and could be interpreted as the users assuming that they already had a sustainable behavior and transportation habits.

The main feedback from the evaluations indicated that the concepts were interesting and motivating. The overall results look positive and convincing enough to continue developing the concept and the Smiling Earth app and the evaluations have provided valuable feedback to enhance as well as simplify the app.

## 5 Conclusion and Future Work

This paper describes a mobile app Smiling Earth, designed to create awareness about carbon footprints and affect individuals' behavior change towards more sustainable actions in their daily lives. The overall research question addressed is the paper is: Can the combination of energy and transport data and individual energy consumption in terms of CO2 emissions motivate people to manage energy better and reduce CO2 emissions? The evaluations show that Smiling Earth has the potential to contribute to raising the awareness of users and motivating them to learn more about how their daily activities could impact the environment through CO2 emissions. The results from the evaluations of the prototype show that the concept of Smiling Earth is interesting and understandable for the users and that it motivates users to change their behaviour to environmentally sustainable habits. However, work remains to get users to actively use Smiling Earth and sustain behaviours that emit less CO2.

The future plans for this work include further development of the concept and prototype based on the users' feedback and enhancing capabilities such as the social aspects, user communities and enhancing the gamification aspects for intrinsic motivation

and raising the users' curiosity to support behaviour change. We also plan to conduct more evaluations with other user groups; e.g. car owners.

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