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Programmes division
National Research Programmes

Full Proposal: Scientific Part
NRP 71 "Managing Energy Consumption"

Division IV, National Research Programmes (NRP)

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Project title (English)	***GoEco!* A community based eco-feedback approach to promote sustainable personal mobility styles**

1. Research

1.1 State of research in the field

GoEco! faces the challenges presented by "Module 1 Society – Options for changing mobility and transport behaviour" in NRP71. It tries to answer the following research questions proposed by the call for project:

- "how to exploit potentials for consciously refraining from engaging in energy-intensive behaviours in the mobility sector?"
- and "which social processes and framework conditions can lead to sufficiency oriented forms of mobility behaviour?".

In particular, *GoEco!* aims at understanding whether eco-feedback information, social comparison and peer pressure can be effective in fostering changes in personal mobility behaviour, facilitating the long-term challenge to reduce private motorized transport and bringing about a transition to different mobility options, such as vehicle-sharing, intermodal use of means of transport, public transportation and slow mobility.
To this purpose *GoEco!* adopts an inter-disciplinary, bottom-up approach, aimed at exploring the potential effects of smartphone-based virtual communities through field experimentation and direct interaction with the end-users.
The project is situated at the crossroads of different research branches and open challenges:

- Energy sciences: going beyond the traditional awareness raising approach in promoting the transition to low carbon and less energy-intensive mobility styles;
- behavioural sciences and sociology: assessing the effectiveness of eco-feedback and competitive schemes in triggering collective behaviour change;
- "gamification": using game design elements in non-leisure contexts;
- information and communication technologies: exploiting smart mobile devices as tools to provide inexpensive sensing of mobility behaviour (crowdsourcing) and to suggest energy-efficient alternative mobility options (intelligent transport systems ITS);
- geomatics and artificial intelligence: using machine learning and data-mining techniques to understand mobility patterns (trajectories and motivations).

Research activities involving real-life users in complex, real-world settings can be addressed as "Living lab experiences" [Higgins and Klein, 2011], i.e. processes allowing to develop, deploy and test new strategies capable of responding to our changing world (MIT Living lab website http://livinglabs.mit.edu, retrieved online on March 12th, 2014).
In the mobility sector, successful Living lab experiences are, for example, being performed to assess the potential for the diffusion of electric mobility (see the Canton Ticino e-mobiliTI project [Cellina et al., 2013] or the Danish Insero TryAnEV/E-Mobility Living Lab project, http://e-mobility.insero.com/Living-lab/the-foundation-of-living-lab, retrieved online on March 16th, 2014).

The actor-based Living lab framework offers an ideal test-bed to assess effectiveness of the persuasive technology approach [Fogg, 2003] or the [Thaler and Sunstein, 2008] approach for enhancing sustainability transitions. Recent research in the energy field has mainly focused on the transition in household energy consumptions, especially electricity, towards smart-grid electricity systems (reduction of global consumptions and management of the peak load demand). Pilot projects developed so far monitored the electricity consumptions through smart meters installed in each household, using displays, websites or smartphone applications to let users visualise their real-time consumptions in a user-friendly way (eco-feedback approach: [Darby, 2000, 2006 and 2010; Fischer, 2008; Burgess and Nye, 2008; Faruqui et al. 2009; Hargreaves et al. 2010 and 2013; Weiß et al., 2010; Schleich et al., 2011; Degen et al., 2013]).
Acknowledging that feed-back mainly informs and, even when it is simple and customised, in the long term is not able to motivate an enduring change [Ai He et al., 2010, Darby 2006 and 2010; Degen et al., 2013; Vine et al. 2013], in some selected cases users were provided with the opportunity to define personal objectives and to engage in challenges for behaviour change [Froehlich et al., 2010; Bull et al., 2013]. Some advanced projects also allowed for social comparison: providing opportunities to share objectives and performances in virtual communities such as Facebook or Twitter, they provided the user with a social trigger to change [Mankoff et al., 2007, 2010; Lehrer and Vasudev, 2011; Petkov et al. 2011; Foster et al. 2010, 2011; Weiß et al., 2012, Foster and Lawson, 2013; De Luca, 2013; https://social.opower.com/explore].
All these experiences share the emerging "gamification" approach, developed in the Human-Computer Interaction field [Deterding et al., 2011] on the basis of past psychological literature (see for example [Malone and Lepper, 1987]): "achievements", "rewards", "goals", "challenges", "feedbacks", "cooperation", "competition" are all keywords characterizing this approach.
Effective attempts to face real-life problems, with "gamification"/Alternate Reality Games (ARG) approaches were already performed, among the others, within processes for general behaviour change at the society level [McGonigal, 2011] and for training and education purposes (e.g., [Kapp, 2012]). From the very beginning, "gamification" was regarded as particularly interesting when coupled with smartphone applications [Zichermann and Cunningham, 2011].

Similar paths can be recognized in the efforts to reduce water consumption in households: acknowledging the need for an active involvement of the end-users in order to save water and use it in a rational way [Fraternali et al., 2012], some pilot projects favoured water smart metering [Anda et al., 2013] and developed user-friendly displays of the consumptions (Amphiro, [Fischli et al., 2011], [Tiefenbeck et al., 2013a and 2013b]). Recent research, for instance within ICT EU funded projects, is exploring "gamification" approaches with virtual communities of households (e.g., the SmartH_2O project [Rizzoli et al., 2014], by one of the authors of the present project proposal).

Automatic monitoring of energy consumptions in the mobility sector, instead, is much more complex, since a static monitoring system is insufficient: a flexible tracking system, able to follow the users along their movements, is necessary. The availability of affordable GPS devices and the large-scale diffusion of smart mobile devices opened novel research perspectives: in the last cou-

ple of years some pilot projects aimed at automatic travel data tracking were developed, also in Switzerland [Schüssler and Axhausen, 2009; Jariyasunant et al., 2012; Nitsche et al., 2012; Kiukkonen et al., 2010; Ythier et al., 2012; Brignoni and Marconi, 2013], including those performed by the research team involved in the present project proposal [Raubal, 2011; Raubal 2012; Yuan et al. 2012; Cellina et al., 2013]. Also, commercial applications for smart mobile devices are now available, mainly developed for health promotion and sport reasons (personal trainers): among the most downloaded applications are "Moves" [http://www.moves-app.com, retrieved online on March 16th, 2014] and "Endomondo" [http://www.endomondo.com, retrieved online on March 16th, 2014], which both track travels made by bike and foot (walking and running), with increasing precision and accuracy, and with a very communicative and user-friendly graphical interface.

In such context, a few experiences of smartphone-based eco-feedback processes with specific mobility-sector objectives were gained (e.g., [Froehlich et al., 2009]). The FP7 SUPERHUB project [Gabrielli et al., 2013], in particular, is currently exploring triggering behavioural change by letting the user define personal goals and providing her with regular feedback and support by info-mobility applications (travel planners, real-time public transport planners, car/bike-sharing management tools).

However, in the mobility sector only a few small-scale attempts were made to explore the combined effects of smartphone-based travel tracking and virtual communities in triggering behaviour change. To our knowledge only [Jylhä et al., 2013] and [Bie et al., 2012-FP7 SUNSET project] are testing similar ideas.

Moreover, the role and potential of travel information systems in fostering behavior change are largely unexplored. Integrated multimodal travel information systems and multimodal route planners are still niche applications [Chorus et al., 2006, Kenyon and Lyons, 2003]. However, some services offer limited multimodal travel and route planning functionalities. The website of the Swiss Federal Railways (http://www.sbb.ch) offers a tool to plan trips from door to door, incorporating walking and various modes of public transportation (e.g. train, bus, tramway, ship etc.). It also compares travel time, energy consumption and CO_2 emission with a corresponding trip by car. Google Maps (http://www.maps.google.com) offers the functionality to plan a trip by car, by public transit, by bicycle, by foot or even by plane. However, planning a trip involving several different modes of transportation is not possible. Furthermore, information from the energy point-of-view is missing. The British tool *Transport Direct* (http://www.transportdirect.info/) enables the comparison of public transport options with car routes. Besides a comparison of trip costs, the tool also provides information about CO_2 emissions. Ferreia (2014) reports on the Green Route Application, which is an integrated multi-modal route planner taking into account real-time traffic information and CO_2 policies. Besides public transportation and car as modes of transportation, also taxi, walking, car- as well as bike-sharing are considered. Kramers (2014) claims that persons who wish to choose the most environmentally friendly routes are barely supported by today's travel information systems. She emphasizes that sustainability-oriented travel information systems should provide information about no-trip alternatives such as virtual meetings, information about alternatives for shorter journeys and information about travel alternatives incorporating different modes.

Therefore, these promising research lines are fully open to exploration.

1.2 Personal contribution to research in the field

Here we provide a short description of the expertise of the applicants and of the inter-disciplinary research groups involved in the project.

PI Roman Rudel has a wide experience in the management of interdisciplinary research projects in the field of environmental economics and technological innovation processes, with a strong focus on the interface between environmental and social aspects. He is currently head of the Institute for Applied Sustainability to the Built Environment (ISAAC) and supervises several projects based on participatory and Living lab approaches, in particular in the fields of mobility and renewable energies: we highlight here the previously mentioned e-mobiliTI project, aimed at understanding opportunities and barriers to the diffusion of electric mobility in Canton Ticino, and the Swiss to Grid project [Rivola et al., 2013], aimed at studying and testing opportunities and drawbacks for decentralised production, storage and management of electricity from renewable sources (photovoltaics), in a smart grid framework.
In *GoEco!* he will coordinate SUPSI researchers from three different institutes:

- the Institute for Applied Sustainability to the Built Environment (ISAAC) will engage Francesca Cellina, a researcher experienced in participatory processes and decision support systems (DSS) for energy and natural resources management. Currently, her research activities focus on sufficiency and sustainable lifestyles, stakeholders integration and conflict management (Living labs) in the energy sector, with a special interest for the mobility sector;
- the Dalle Molle Institute for Artificial Intelligence (IDSIA) will engage Andrea E. Rizzoli, who is currently co-ordinating the EU FP7 project SmartH2O, which develops an ICT platform for leveraging on social computation for urban water management. He is also active in the fields of Smart Grid research and DSS for optimisation and management of industrial and natural processes;
- the Interaction Design Lab of the Laboratory of Visual Culture (LCV) will engage Massimo Botta, Vanessa De Luca and Luca Morici. Massimo Botta is the head of the interaction design lab where he leads applied research projects in the fields of interaction design, user interfaces, web and mobile applications, information visualization systems and digital archives. Currently, he is leading the development of multichannel platforms and mobile applications to foster users behaviour change in smart grid systems. Vanessa De Luca is a researcher and designer, specialized in user experience, interaction and game design; she is currently involved in multidisciplinary projects addressing playful interactions to foster user engagement in energy saving challenges. Luca Morici is a sociologist and an expert in qualitative research methodologies. He participates in projects and researches in the field of visual communication.

Co-PI Martin Raubal is currently head of the Institute of Cartography and Geoinformation at ETH Zürich and leads the Geoinformation Engineering (GIE) group. GIE deals with questions related to mobility and renewable energies from a geospatial perspective. More specifically, the group's expertise covers the analysis of people's mobility patterns (such as from mobile phone data trajectories), the design and testing of location-based services and spatio-temporal similarity analyses. In addition, the group is active regarding the utilization of GIS for renewable energy planning and spatio-temporal location optimization (e.g., wind, solar and combined biogenic heat and power plants).

Besides the applicants and the groups introduced above, the following researchers have agreed to actively participate in the project, though not being funded by SNF (external collaborators):

- Kay Axhausen is Professor of Transport Planning at ETHZ (Institute for Transport Planning and Systems). He has wide experience in measurement and modelling of travel behaviour. His current work focuses on the microsimulation of daily travel behaviour and long-term mobility choices and the response of the land-use system to those choices. Prof. Axhausen will be involved in the design and set-up of the user studies and the analysis of the users' mobility behaviour.

- Christoph Hölscher is Professor of Cognitive Science at ETHZ (Department of Humanities, Social and Political Sciences). His research focuses on spatial cognition and usability for architectural design, Human Computer Interaction, and user modelling and personalization. Prof. Hölscher has wide experience in designing and performing human participants tests and will therefore contribute his knowledge to various aspects of our user studies.
- Piero Fraternali is Professor of Web Technologies at Politecnico di Milano (Dipartimento di Elettronica Informazione e Bioingegneria). His main research interests concern software engineering and methodologies and tools for web application development, multimedia information retrieval and human computation. Prof. Fraternali will be involved in the development and testing of the conceptual framework for the gamification activities.

GoEco! activities will be developed in close connection with the research activities performed within the recently approved Swiss Competence Centre for Energy Research (SCCER) on "Efficient Technologies and Systems for Mobility". Both *GoEco!* applicants are actively involved in this SCCER, with reference to the capacity areas B.1 Integration, Operation and Optimization of Mobility Systems and B.2 Integrated assessment of mobility (Topic B.2.4 socio-economic aspects). This close connection to the SCCER offers a large potential for synergies regarding activities, such as application development and testing. The results of *GoEco!*, especially the data generated during the user studies, can be utilized for further impact analyses and within the agent-based transportation simulation framework Matsim, led by Prof. Kay Axhausen, who is also involved in *GoEco!* as mentioned above.

1.3 Detailed research plan

Objectives

The main objective of the project is to investigate if and how information feedback and social interactions (social comparison and peer pressure) can be effective in fostering changes in personal mobility behaviour, facilitating the long-term challenge to reduce private motorized transport and bringing about a transition to different mobility options, such as vehicle-sharing, intermodal use of means of transport, public transportation and slow mobility.
The wide acceptance of smart mobile devices (phones and tablets) enables us to run a medium-to-large-scale Living lab experiment with a significant number of users sharing information about their mobility behaviour and receiving feedback on their choices.

Within *GoEco!* the users test a smart-device application developed on purpose, that challenges them to reduce personal vehicle use:

- by tracking their trips, providing them with feedback on their mobility behaviour and suggesting alternative, low-impact modal options, and letting users define personal reduction objectives and targets;
- and by creating a virtual community among them, setting up a social comparison rewarding scheme which acts as a further trigger to stimulate behaviour change.

To get a broader understanding of the phenomenon, the Living lab is run both in Canton Ticino and in the City of Zürich, two contexts which are very different both in the supply of mobility options and in the socio-cultural attitude of the population towards mobility.

In order to get a deeper insight on the users' perceptions and attitudes and to strengthen the results of the Living lab, a selection of participants to the Living lab will be closely followed throughout the experiment, by means of focus groups and interviews.
Such a process will allow us to understand how major socio-economic variables such as gender, age, education and income influence attitudes and perceptions towards mobility. Moreover, it will also provide the chance to identify the main opportunities and barriers for change and to gather

bottom-up suggestions for local public authorities (on land-use and transport planning and work- and leisure-time organisation) in order to result in a wider and deeper change at the general society level.

Background and project framework

Our research is based on the acknowledgement that previous attempts towards sufficiency by stimulating the user awareness and increasing information, such as well-known campaigns "Multimobil unterwegs" [Stadt Zürich, 2013], "Bike to work", "Slow up", "Home office day" and so on, have been of limited impact in the promotion of a mass transition towards low energy and low carbon mobility options. The rate of transition towards sustainable mobility choices has in fact been slow, even though:

- the present urban system, tailored for cars, has long shown its limitations (dependency on oil, carbon emissions, air pollution, noise, soil consumption, traffic congestion, safety etc.);
- in urban areas alternative and effective transport modes are already available, ranging from well-established systems such as the public transportation and slow mobility networks, to emerging alternatives such as vehicle-sharing systems.

This is particularly true in the Italian and French speaking part of Switzerland, where individual motorised traffic is responsible for more than 70% of the daily covered distances, however continues to be an issue also in the Swiss German Cantons, where it accounts for around 60% [OFS/ARE, 2012].

Changing collective mobility behaviour towards sustainable lifestyles is particularly difficult, since at the individual level private motorised transport keeps being perceived as positive and desirable, while attempts to reduce it are limited by social and psychological barriers, such as the fear for sacrifices (decrease in personal freedom, flexibility and comfort), the fear to return to the past (slowness and incapability of keeping pace with the demands of our society), the fear to lose social prestige (the car as a status symbol) [Diekstra and Kroon, 1997; McKenzie-Mohr, 2000].

Moreover, even when people are strongly motivated to change their behaviour and effective alternative mobility options exist, permanent changes are difficult to be attained. This is probably because, besides high motivation and practical feasibility, effective behavioural change requires a further trigger, capable of persuading people to action [Fogg, 2003 and 2009]. Deeply investigated top-down policies, such as providing monetary subsidies or fiscal incentives or introducing regulations, are generally too costly or imply high levels of social conflicts and oppositions, therefore only in some cases they prove to be effective, long term triggers. Indeed, research in social and environmental psychology has shown that one of the most powerful triggers for sustainability transition lays in providing bottom-up personal feedback and comparison with the behaviour and performances of other members of the community (peer pressure): individual feedback and social comparison activate competition and a strive to stand out among peers as a reference point and as an example [see for example Alex Laskey's talk on *TED - Ideas worth spreading* or Oullier, 2013].

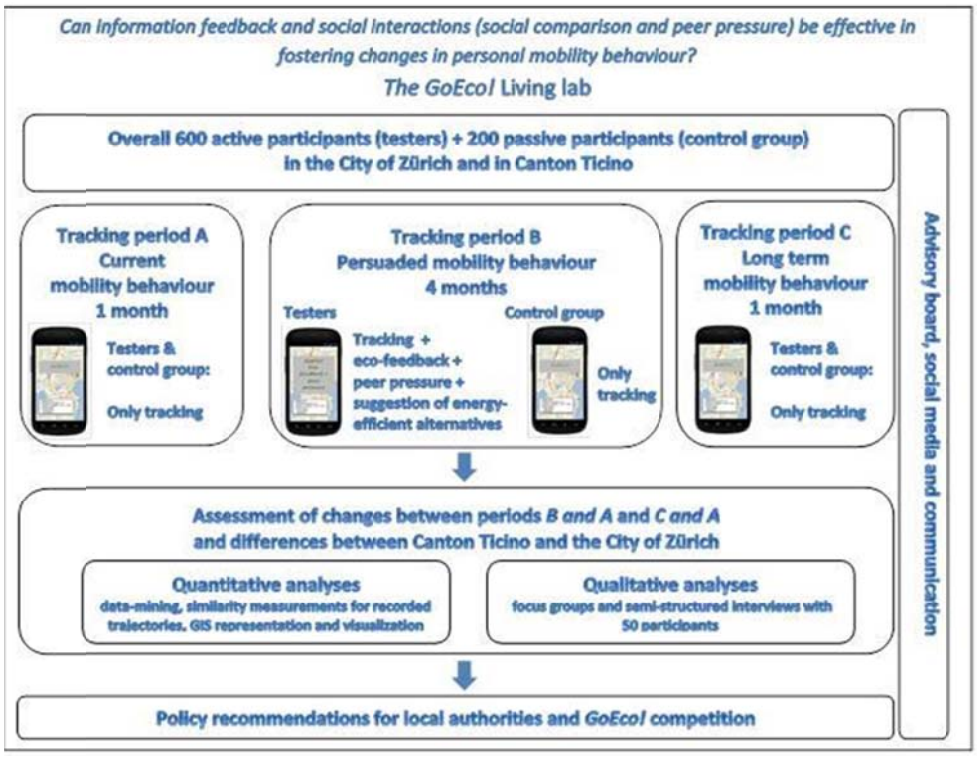
In this framework, the diffusion of digital technologies and in particular of social media, community-based systems and smartphones opened new research opportunities: the relative ease of availability of GPS applications and algorithms able to track single people movements with sufficient level of detail, combined with mobile sensing opportunities [Lane et al., 2010] and the ease of creating virtual communities among the users of mobile digital applications, seem to offer very promising triggers to promote long-lasting behaviour changes also in the mobility sector: smart mobile devices can be powerful tools to enhance user engagement and collaborative empowerment towards complex sustainability transitions.

Methodology and activities

GoEco! proposes an inter-disciplinary approach, which is directly reflected in the composition of the project team, able to integrate general sustainability and transition science competences with expertise in computer sciences, user centred design (UCD) and geomatics. Therefore, the project will combine quantitative and qualitative approaches: by means of a smartphone application developed on purpose, it will track the mobility patterns of the members of the Living lab and assess their performances (reduction of kilometres travelled, modal change obtained, energy consumptions and CO_2 emissions avoided etc.); furthermore, it will involve a sub-set of them to discuss their mobility choices, by means of interviews and focus groups.
Project activities are structured in six work packages, summarized in the table and pictured below and described in greater detail in the following pages.

Work Package	Task	Responsible	Methods and comments
0 – Project management	0.1 Project management	SUPSI - ISAAC	- At least 5 general project meetings, plus frequent meetings at the work-package/task level - Use of an online project management platform such as 'Basecamp' - Traditional communication through phone and e-mail
1 - Creation and management of the Living lab	1.1 Communication and recruitment of the participants (testers + control group)	SUPSI – LCV ETHZ	By local communication and promotion we involve: - 600 participants to test the application (total, ZH+TI) - 200 participants to enter a control group (total, ZH+TI)
	1.2 Tracking period A - current mobility behaviour	SUPSI – ISAAC ETHZ	General training for the use of the application for two weeks (tracking period 0); then, user support for 1 month of tracking. The smart-mobile application does not provide the users with feed-back.
	1.3 Tracking period B – persuaded mobility behaviour	SUPSI – ISAAC ETHZ	User support for 4 months of tracking. Testers: the smart-mobile application provides them with regular eco-feedback, individual challenges and social comparison. Control group: the smart-mobile application does not provide them with feed-back.
	1.4 Tracking period C – long term mobility behaviour	SUPSI – ISAAC ETHZ	General user support for 1 month of tracking, one year after tracking period B has ended, both for testers and control group. The smart-mobile application does not provide them with feed-back.
2- Assessment of the performances of the Living lab	2.1 Elaboration of general statistics on the user mobility behaviour during periods A, B, C	SUPSI – IDSIA ETHZ	Use of data-mining, space-time analyses (e.g., time series analyses), similarity measurements for recorded trajectories, GIS visualization and representation. The analysis also highlights changes over time in the users' mobility behaviour (how long do they take to change their mobility patterns?)
	2.2 Comparison of the users behaviour during period B and period A (short-term assessment)	SUPSI – ISAAC SUPSI – IDSIA ETHZ	Analysis of quantitative data produced in 2.1 + focus groups and individual structured interviews with a subset of both the testers and the control group (around 50 persons: 40 testers and 10 members of control groups).
	2.3 Comparison of the users behaviour during period A and period C (long-term assessment)	SUPSI – ISAAC SUPSI – IDSIA ETHZ	Analysis of quantitative data produced in 2.1 + focus groups and individual structured interviews with a subset of the testers (around 40 persons).

	2.4 Comparison of the results in Canton Ticino and in Zurich City and general suggestions for the local public authorities	SUPSI – ISAAC ETHZ	Analysis of quantitative and qualitative data produced in 2.1, 2.2 and 2.3. Suggestions for authorities will refer to land-use and transport planning, work- and leisure-time organisation.
	2.5 Elaboration of general statistics on the use of the app over time	SUPSI - LCV	Analysis of how long the users keep in using the app on a regular basis helps to assess the effectiveness of the application as a tool to foster behaviour change.
3- Development of the smartphone application – Persuasive feedback and user interface	3.1 Identification of the relevant mobility behaviour eco-feedback parameters: • individual self-monitoring; • individual goal setting; • competition and social comparisons; • rewarding scheme for the use of the app itself.	SUPSI –ISAAC SUPSI – LCV ETHZ	Feedback parameters will be identified also using focus groups with a sub-set of the testers (around 40 persons). A specific feed-back mechanism will also be developed to keep the use of the app high over time, by means of a rewarding scheme allowing to access to mobility-related prizes (tickets, trial subscriptions, …) or charitable gifts at the end of the tracking periods.
	3.2 User Experience and Interface Design of the smartphone application	SUPSI - LCV	User Centred Design (UCD) methodology to design the mobile user interface with a target group (subset of the testers, 5 persons). Definition of the User Experience and design of the User Interface for the smartphone application.
4- Development of the smartphone application - Algorithms and ICT architecture	4.1 Mobility travel tracking and automatic feed-back to the users	SUPSI – LCV	Interaction with the “Moves” application, server for data storage, architecture of the system
	4.2 Algorithm to identify the places visited and to infer the reasons for the trips	ETHZ	Development of algorithms able to infer the reason for the trips, based on the places people visited [use of map matching algorithms].
	4.3 Algorithm to learn modal choice and places visited based on past behaviour (modal information)	SUPSI - IDSIA	Development of machine learning algorithms and use of data-mining techniques in order to let the app learn the mobility patterns of the users, based on the repetition over time of the trips they make.
	4.4 Algorithms to identify alternative modal options/energy-efficient routes	ETHZ	Alternatives might be derived using the trips by other users or the information included in existing databases. Being identified by post-processing analyses, they will be suggestions for future trips, not real-time indications.
5- Implementation and dissemination	5.1 Establishment and management of the *GoEco!* advisory board	SUPSI – ISAAC ETHZ	The advisory board, made of practitioners, stake-holders and academic experts will be established since the very beginning.
	5.2 Creation of an online community: set-up of and regular update of a project website and accounts on major social media	SUPSI – LCV	Activities made throughout the project, in order to favour technology transfer at the society level (community building through social media). The website and social media are both tools for the recruitment and management of the participants to the living lab and tools for dissemination to the wider public. Activities are performed both in German and in Italian.
	5.3 Dialogue with local mass-media, participation to non-scientific conferences and organisation of a project final conference	SUPSI – LCV, SUPSI – ISAAC ETHZ	
	5.3 Participation to scientific conferences and publication in scientific journals	The whole *GoEco!* team	Elaboration of papers and presentations for the scientific community. The open access standard will be favoured whenever possible.



- *WP0 - Project Management*

The goal of WP0 is to ensure an efficient coordination and administration of the whole project, to foster co-operation and seize emerging opportunities within the project, to ensure trouble-shooting if problems arise, to supervise progress, and to ensure communication with the Steering Committee of NRP71.
Being an inter-disciplinary project, *GoEco!* involves researchers from two universities (SUPSI and ETHZ), part of four different research institutes (SUPSI: ISAAC, IDSIA, LCV; ETHZ: IKG), not to mention the external collaborators (ETHZ IVT, D-GESS and Politecnico di Milano).
Therefore project management requires a substantial effort for the coordination of the activities.
To achieve this, we plan at least 5 general project meetings during the whole project and frequent meetings at the work-package/task level. Besides traditional communication through phone and e-mail, we plan to use a project management platform such as the "Basecamp"' tool (https://basecamp.com), which enables to share information, to manage to do's and to facilitate communication.

- *WP1 - Creation and management of the Living lab*

This Work Package refers to the creation of the Living lab, with the direct involvement of end-users, and to the activities which will be performed within it.
Since considering different socio-cultural and infrastructural contexts can provide significant insights for behaviour analyses, the Living lab experiment will be performed both in Canton Ticino and in the City of Zürich.
Overall, we expect to involve around 800 volunteer end-users; they will be recruited through communication campaigns on local mass-media and social networks and their long-term involvement will be enhanced by incentives such as prize draws and (charitable) gifts. We will look for a representative sample of participants (according to gender, age, main socio-economic variables) – however we can expect a bias regarding their inclination to use new technologies

(smartphones). This is acceptable, considering that diffusion of the smartphone technologies will further increase in the next years.
Each participant will be asked to sign a statement allowing us to collect and analyse data regarding her movements and we will commit to perform analyses in strict compliance with the regulations by the ETHZ Ethics Committee and by the SUPSI Board.

Activities within the Living lab will be as follows:

- the volunteers will first be involved in a two weeks tracking period (tracking period 0), during which they will learn how to use the application and, at the same time, the application will learn about their most frequent trips (means of transport used and places visited – see WP4);
- then they will enter a one-month tracking period, during which the *GoEco!* application will track all their trips, however without providing them with any type of feedback or peer pressure mechanism (tracking period A). This will allow to identify their *current mobility behaviour*;
- later, the volunteers will be divided into two groups: for four months (tracking period B) 600 of them will actively test the *GoEco!* application, with the eco-feedback and social comparison functionalities, while 200 of them will enter a control group, i.e. they will keep being monitored as in tracking period A (neither feedback nor social comparison). During this period, the *persuaded mobility behaviour* will appear;
- finally, around one year after the end of tracking period B, the volunteers will again be monitored for one month with the *GoEco!* application, without feedback or social comparison. This will allow to identify their *long-term mobility behaviour* and to find possible permanent changes with respect to their current mobility behaviour.

Activities to recruit the users, to train them to the use of the *GoEco!* application and to provide them with technical support are all included in this Work Package.

- *WP2 - Assessment of the performances of the Living lab*

This Work Package is responsible of the elaboration of the quantitative and qualitative analyses of the mobility performances of the end-users involved in the Living lab.

Quantitative analyses will use data-mining and machine learning techniques, time-series analyses and GIS representations and visualisations, and will mainly be automatic processes. A main focus will thereby lie on the spatio-temporal analyses of the recorded trajectories and the performance of similarity measurements for these. Such analyses will be performed for each user both on a daily basis, since they are necessary to develop the eco-feedback indications, and at the end of each tracking period (A, B and C). The latter will allow us to identify the *current*, *persuaded* and *long-term mobility behaviour* of each end-user.

An automatic comparison between the *current* and *persuaded* mobility styles and between the *persuaded* and the *long-term* mobility styles (respectively, short-term and long-term assessment) will also be performed for each end-user: comparing the intensity of change in the mobility styles between periods A, B and C respectively for the testers and the control group will allow assessing the effectiveness of the eco-feedback and social comparison mechanisms. Analyses will also be performed to highlight changes over time in the users' mobility behaviour and to understand how long they take to change their mobility patterns. Finally, we will also analyse the use of the application itself over time, which is an essential aspect in assessing its effectiveness: should the users soon quit using it, we might expect little changes in their mobility behaviour.

Important insights on such results will be produced by focus groups and individual semi-structured interviews with a sub-set of both the testers and the control group members. As a whole, we plan to develop these qualitative analyses with around 50 participants, 10 of which will be members of the control group. This sub-set of participants will be selected in order to

have sufficient variability in the main socio-economic variables (gender, age, education, income); thus, the envisioned qualitative analyses will allow us to understand how these variables themselves influence attitudes and perceptions towards mobility. Moreover, these analyses will allow us to develop general suggestions regarding land-use and transport planning, work- and leisure-time organisation for local authorities who wish to favour general behaviour change in the mobility sector (see the Implementation milestone number 5).

- *WP3 – Development of the smartphone application – Persuasive feedback and user interface*

This Work Package deals with the definition of the "gamification" contents of the *GoEco!* smartphone application. Tasks are therefore devoted to the identification of the relevant eco-feedback parameters, which will allow the end-users to:

- monitor their travel performances on a regular basis;
- set personal goals and check their level of achievement;
- enter a social comparison mechanism.

A specific feed-back mechanism will also be developed to keep the use of the application high over time: a scoring scheme will be used to monitor the use of the app and at the end of the tracking periods, users with the highest scores will be rewarded with mobility-related prizes (tickets, trial subscriptions, …) or charitable gifts.

All the eco-feedback parameters will be identified also using focus groups with the sub-set of the testers involved in the Living lab already mentioned in WP2 (around 40 persons).

Closely correlated with this is the task aimed at developing the graphical user interface of the *GoEco!* application. To facilitate the analyses of time-series data of each single end-user, the smartphone application may be supported by a web interface, accessible on the *GoEco!* website (see WP5) after authentication. Both the interfaces (smartphone and website) will be designed adopting a "User Centred Design" (UCD) methodology approach, involving a target group of end-users, comprised of around 5 persons, chosen from the previously mentioned sub-set of users.

- *WP4 - Development of the smartphone application – Algorithms and ICT architecture*

This Work Package develops the ICT infrastructure to support the project. After a thorough evaluation of a number of prototypes and commercial applications for smart mobile devices developed so far, we decided to use the existing commercial application "Moves", available for both Android and iOS smartphones (version 1.5 released on November, 26th 2013). We will purchase a copy for each participant to the Living lab and use this application to track her movements. The "Moves" application exposes an API (application programming interface) which allows access from external apps to the tracking data (https://dev.moves-app.com). We will therefore develop the *GoEco!* application that, on a daily basis, will access the tracking data stored on the "Moves" server to perform post-processing analyses. These analyses will provide the users with daily reports on the trips they made, on the places visited, on the kilometres travelled, on the used transport means, also asking them to validate the data retrieved. Furthermore, the *GoEco!* application will support the users with the eco-feedbacks on their mobility performances and the peer comparison functionalities developed in WP3.

The *GoEco!* application will be as simple as possible from the users' perspective: they will only be asked for a general validation of the quality of the data tracked, on a daily basis. To this purpose, using machine learning and data-mining algorithms, the application will be able to learn the mobility patterns of the users based on the repetition over time of the places visited and means of transport used. Moreover, using map matching algorithms, it will be able to infer the reason for the trips, based on the places people visited.

As a further activity, the *GoEco!* application will be enriched with functionalities supporting the end-user in the choice of energy-efficient routes by methodologies and algorithms developed at ETHZ. Always using post-processing analysis, at the end of each day more efficient travel alternatives will be suggested to the users: they will, for example, be indicated the time-table of public transport lines or the presence of shared means of transport in the surroundings of the places they visited, so that they can consider them in future trips between similar starting and ending points. Such alternatives may either be identified using data directly extracted from the peers (the other users), by means of trajectory-based similarity measurements [Rieser-Schüssler and Axhausen, 2013], or be identified using information included in existing data-bases, such as the public transportation lines and stops, and the parkings for shared means of transport (bike or car sharing).

To favour accessibility and further upgrading of the *GoEco!* application, we propose to release its source code under the open source GNU General Public License v3 after the completion of the project. GPL v3 license (https://www.gnu.org/copyleft/gpl.html) is a license that preserves the right of the software to stay free, under the same conditions we establish when we release it. This license is well suited to basic research projects, where the spread and diffusion of ideas and methods is most important.

- *WP5 – Implementation and Dissemination*

This Work Package includes all the activities which favour dissemination of the objectives and results of the project and their implementation on a wider scale. They are described in detail in Section 2.2.

1.4 Timetable and milestones

Project activities are expected to start on **1.01.2015** and to last for **36 months**. The following chart describes their time schedule, the main milestones and the project deliverables (red circle).

		Year 1												Year 2												Year 3											
WP	**Task**	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
0	0.1 Project management																																				
1	1.1 Communication and recruitment of the users												**1**																								
	1.2 Tracking period A																																				
	1.3 Tracking period B																																				
	1.4 Tracking period C																																				
2	2.1 General statistics on mobility behaviour																																				
	2.2 Short-term assessment of mobility behaviour change																										**2**										
	2.3 Long-term assessment of mobility behaviour change																																				**3**
	2.4 Comparison TI-ZH																																				**4**
3	3.1 Identification of the eco-feedback parameters													**5**																							
	3.2 User Experience and Interface Design													**6**																							
4	4.1 GPS tracking algorithms and automatic feed-back													**7**																							
	4.2 Identification of places visited and reasons for the trips													**8**																							

	4.3 Learning on past behaviour													9																							
	4.2 Identification of alternative modal options/routes													10																							
5	5.1 Establishment and management of the advisory board							11																													
	5.2 Online Community: Project website and social network							12																													
	5.3 Communication with local mass media and non-scientific conferences							13																													14
	5.4 Scientific publications and conferences																																				15

Project milestones and deliverables are the following:

1. Participants to the Living lab are recruited, both in Ticino and in the City of Zürich
   Deliverable 1: Report on the selection of the participants to the Living lab
2. Short term assessment of mobility behaviour change is completed (compare B and A)
   Deliverable 2: Report on short-term mobility behaviour change of the participants
3. Long term assessment of mobility behaviour change is completed (compare C and A)
   Deliverable 3: Report on long-term mobility behaviour change of the participants
4. Comparison between the effects on long term behaviour change in Ticino and Zürich is done and guidelines for local authorities are completed
   Deliverable 4: Report on geographical differences in behaviour change
   Deliverable 5: Guidelines for local authorities: policy recommendations on how to favour mobility behaviour change (land-use and transport planning, work- and leisure-time organisation)
5. Effective eco-feedback and social comparison parameters are identified
6. Graphical user interface is defined
7. Algorithms and system architecture for the *GoEco!* smartphone application are defined
8. Algorithms to infer the reasons for the trips based on the places visited are defined
9. Algorithms to learn based on past behaviour (modal choice and places visited) are defined
10. Algorithms for the identification of energy efficient routes are defined
   Deliverable 6: The GoEco! smartphone application

[For the following milestones and deliverables, please refer to WP5 description in Section 2.2]

11. The *GoEco!* advisory board is set up (during the whole project: at least 4 meetings)
12. Project website is online; Twitter and Facebook accounts are active. From this date on, these media outlets are regularly updated when new events happen in the Living lab
13. Press conference for the launch of the project and the recruitment of the participants to the Living lab
14. Final conference to present results of the project and to release of the *GoEco!* smartphone application
   Deliverable 7: Final conference, updated and final version of the GoEco! project website
15. *GoEco!* contributions are presented in scientific conferences and ISI papers are published in scientific journals
   Deliverable 8: Conference proceedings and scientific publications

We propose to release project reports under the open access Creative Commons Attribution-ShareAlike 4.0 International license (http://creativecommons.org/licenses/by-sa/4.0/). This license allows sharing and adapting the content of the reports for any purpose, including commercial ones, as long as attribution to the *GoEco!* project is acknowledged, and the new content will also have to be distributed under the same license, thus preserving its openness.

Also, to favour accessibility and further upgrading of the *GoEco!* application, compatible with the App store restrictions, its source code will be released under the open source GNU General Public License v3.

2. Implementation

2.1 Previous achievements in knowledge and technology transfer

The applicants have a wide experience in knowledge and technology transfer towards society and the praxis sector. Besides contacts at the federal level, mainly regarding activities with the Federal Department of the Environment, Transport, Energy and Communications (DETEC) and the Energy competence centre SCCER 6 "Efficient Technologies and Systems for Mobility", here we highlight specific contacts at the local level.
First of all, SUPSI is an institution committed to applied research. Therefore, researchers in SUPSI can count on systematic and fruitful collaboration with the main public authorities and stakeholders at the local level in Canton Ticino. Also ETHZ researchers operate with a wide network of contacts with local and national stakeholders. With specific reference to the mobility sector and the present project proposal, among the well-established network of contacts of the applicants we can mention:

- the Cantonal authorities for the transport sector, for land use development and for environmental protection;
- the City of Lugano and the city of Zürich;
- infoVEL, the Centre of competence for sustainable mobility based in Mendrisio;
- ElectricFeel Mobility Systems, an ETHZ spin-off company developing cutting-edge ICT solutions for the planning and management of electric bike transportation systems;
- ESRI Schweiz AG, the world market leader in Geographic Information System software.

Furthermore, SUPSI has specific expertise in technology transfer to the wide society level: within the above mentioned e-mobiliTI project (http://e-mobiliti.supsi.ch) and also within the ongoing S2G projects (http://www.s2g.ch), SUPSI researchers work in close contact with common citizens (Living labs) with the aim of understanding opportunities and barriers respectively to the diffusion of electric mobility and of photovoltaic power plants, as main components of smart electricity grids.
Also, SUPSI researchers operate as scientific consultants for a variety of local administrations (Ticino Canton and Municipalities) in the energy sector (local energy plans, energy policies): such activities are particularly effective in favouring transfer of innovation concepts, procedures and technologies to practitioners and also to common citizens.

Moreover, being recognised as experts in such fields, both SUPSI and ETHZ can count on effective contacts with local mass-media (newspapers, magazines, radio, television), established during previous applied research experiences.

Finally, teaching activities provide another important occasion to favour knowledge and technology transfer. In particular, this is made both within the Architecture, Visual communication, Civil engineering, Mechanics engineering and Electronic engineering bachelor of science/master of science courses at SUPSI and within several courses on GIS, spatial data analysis, and transportation at ETHZ. Moreover, continuing education courses, held both at SUPSI and at ETHZ, offer important chances for direct transfer to practice operators (civil servants, engineers and architects, who often work as consultants for the local public administration).

2.2 Activities planned

Activities for the implementation of the project results are performed in WP5 "Implementation and dissemination", mentioned in Sections 1.3 and 1.4. Here we provide a detailed description.

To favour effective implementation of the results of the project and to promote dissemination to the general public of end-users, we plan to actively involve a selection of practitioners, from the very beginning of the project. They will be invited to join the *GoEco!* advisory board, a voluntary body which will follow the development of the project, whose composition and role are described briefly in the Section below.

Within the general public, our main target are citizens aged between 25 and 44: according to [Nielsen, 2013], this is the slice of the population which is more familiar with everyday use of smart device applications (Nielsen data actually referred to Italy but we believe they can be extended to Switzerland). Considering the present composition of the Swiss population [Population and Households Statistics (STATPOP), 2012], this means that the target audience comprises around 2'261'000 people throughout Switzerland.

Methodologies, activities and tools aimed at involving the end-users in participating in the *GoEco!* Living lab were already described in the Sections above. In particular, recruitment of the participants to the Living lab will be performed by means of a wide communication campaign, targeting the general public. Therefore, since the very beginning the general public will be informed about the project existence, aims and objectives.

Also, a project website (in the form of a blog) will be set up at the very beginning of the project and will be regularly updated, with the aim of informing both the living lab participants and the general audience. In parallel, accounts on the major social media (for instance Facebook and Twitter) will be activated and regularly updated.

Once the project results will be available, the outcomes of the analyses will be distributed to the general public via both the project website and traditional communication activities, with the involvement of local mass media. We envisage the participation at non-scientific conferences, at SCCER 6-related events and we plan to organise a final project conference. Besides the document reporting the policy recommendations for local authorities (Deliverable 5), if the *GoEco!* application will prove to be effective, its updated version will be released to the general public during the conference. The communication plan will be developed by SUPSI researchers with a wide experience in communication activities, also in teaching.

Besides the release of the *GoEco!* application, to be used on a freely basis by every interested citizen, to enhance and amplify its effectiveness we also envision the possibility to set and launch a new annual campaign at the Swiss level, in the fashion of the "Bike to work" team competition. In order to give life to a *GoEco!* Swiss-level competition, a very ambitious follow-up of the project, the support of the NRP71 experts in technology transfer and communication will be crucial. They will in fact allow us to get a wider resonance among the federal government and cantons and municipalities not directly involved in the project.

Finally, implementation activities also include activities aimed at dissemination within the scientific community, by means of publication in scientific journals and participation in scientific conferences. We expect to publish ISI papers and to present research results in conferences in the following fields: sustainability and energy transition, ICT for sustainability and behaviour change, ICT for mobility optimisation, transport and mobility, and ACM-GIS. The open access standard will preferably be chosen.

2.3 Implementation partners: references and contributions

The main implementation partners are those involved in the *GoEco!* advisory board, which is meant as a voluntary body, invited to follow the development of the whole project.
Its members will be invited to take part in at least four annual meetings: approximately at the beginning and at the end of the project and at the end of each year.

They will be asked to provide advice regarding the evolution of the project, with particular emphasis on:

- the creation of the Living lab and the communication campaign for the recruitment of the participants;
- the definition of the persuasive feedback and peer pressure system;
- the identification of the general suggestions for local authorities to favour behaviour change (regarding land-use and transport planning, work- and leisure-time organisation);
- the dissemination and implementation activities.

Contribution to the project activities by the members of the *GoEco!* advisory board will be made on an "in kind" basis.
Being involved throughout the project, they will be key and effective partners to favour the transfers of its results to the general society, by promoting the diffusion of the *GoEco!* application and, possibly, by launching the *GoEco!* competition mentioned above.

The composition of the *GoEco!* advisory board will reflect contacts with the representatives of the main groups of interest of the mobility sector indicated above. We plan to invite the following groups and institutions:

- Federal authorities in the mobility, energy and sustainability fields: representatives of the Federal Department of the Environment, Transport, Energy and Communications (DETEC), and in particular: Federal Office of Transport (FOT), Federal Office of Energy (FOE), Federal office for Spatial Development (ARE), Federal Office for the Environment (FOE);
- Representatives of EnergieSchweiz;
- Experts from the Academic world: representatives of the Energy competence centre SCCER 6 "Efficient Technologies and Systems for Mobility";
- Transport associations: Pro Velo (bicycle), VCS Verkehrs-Club der Schweiz (public transportation), TCS Touring Club Schweiz (general mobility).

2.4 Timetable and milestones

Since the activities for effective implementation and technology transfer are essential for the success of the project itself, they are integrated in the Gantt chart presented in Section 1.4, to which we refer (see WP5 "Implementation and dissemination" and related milestones).

3. Significance

3.1 Contribution to the realisation of the "Energy Strategy 2050"

The key measures introduced by the "Energy Strategy 2050" for the mobility sector aim at improving energy efficiency of internal combustion engines and at favouring the diffusion of electric mobility; however, the Strategy overcomes a purely technological approach, accompanying them with a set of supporting measures to be performed under the "SwissEnergy" framework, which aim at traffic reduction, also targeting consumer behaviour.
Similarly, the 2013 – 2016 programme of the Swiss Federal Energy Research Commission (CORE) stresses the importance of embracing a socio-technical approach in energy-related research. In particular, it remarks the major role played by consumer behaviour in the reduction of fossil fuel consumptions and emphasizes the need to gain full understanding of the transport choices we make (why, when and how we travel), in order to be able to effectively re-orient them.

Finally, also the "2000 Watt Society" concept highlights the need for sufficiency in the transport sector and suggests addressing consumer lifestyles as a key field of action.
Promoting change as a result of personal, bottom-up decisions rather than top-down mandated requirements and providing real-time information on transport choices, *GoEco!* will thus provide a tangible support for the fulfilment of the "Energy Strategy 2050" objectives.

3.2 Scientific significance

The project faces the problem of behaviour change in the mobility sector, adopting an interdisciplinary approach. In Section 1.1 we already described the present state of research in the fields it deals with and highlighted the main open issues it tries to tackle.
The most important benefit that *GoEco!* can provide to the scientific community is a contribution to transition sciences: it offers a structured insight on the effectiveness of eco-feedback and social interaction "gamification" approaches, performing a critical analysis and identification of advantages and limitations.
Another important aspect is related to the use of automatic monitoring techniques, via the smart mobile devices: a large quantity of data regarding mobility behaviour of people under real-life conditions will be available. In full compliance with privacy regulations, such data could be shared with other research institutions, in order to be used for transport, land use and society modelling.
And finally, though it is not its primary objective, *GoEco!* will also produce improvements in automatic mobility tracking and in real-time mobility optimisation research (intelligent transport systems ITS), for the identification of energy-efficient alternative mobility options.

3.3 Social and economic significance

Using a Living Lab approach and a smart mobile platform, the project will verify the impact of information eco-feedback and social interaction on personal mobility behaviour, investigating if appropriate feedback can favour the transition towards more sustainable lifestyles.
Insight gained regarding the opportunities and barriers for change will first of all provide public authorities (Confederation, Cantons and Municipalities) with concrete advice on how to support the transition. Besides specific suggestions related to the Canton Ticino and Zürich City, also general-value indications will be gathered.
Furthermore, the output of the project will include a smartphone application, which will be made available for free distribution on a broader scale, for example, through the SwissEnergy, SBB and Mobility websites, with the aim of supporting traditional information and awareness raising campaigns. The use of such application might be further encouraged by launching a "*GoEco!"* awareness-raising competition throughout Switzerland, such as the "Bike to work" campaign: experience gained within the *GoEco!* Living lab will in fact provide direct suggestion for its effective creation and management for a new standard for a competitive action addressing single citizens.
Finally, and probably most important, the project will provide national decision-makers and stake-holders of the mobility sector with an effective platform for dialogue: the network and relationships created within the *GoEco!* advisory board will remain over time, open to further fertile experiences.

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