YouPower – A Social App for User Engagement in Power Grids

First Author Name[1], Second Author Name[1] and Third Author Name[2]
[1]*Institute of Problem Solving, XYZ University, My Street, MyTown, MyCountry*
[2]*Department of Computing, Main University, MySecondTown, MyCountry*
{f_author, s_author}@ips.xyz.edu, t_author@dc.mu.edu

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Abstract: The abstract should summarize the contents of the paper and should contain at least 70 and at most 200 words. The text must be set to 9-point font size.

1 INTRODUCTION

This paper presents the design of YouPower, a social smart grid platform that is designed as a means to explore the potential and challenges of supporting social participation, awareness and engagement of power gird users (`https://app.civisproject.eu`). The goal of developing such a system is to make energy visible, to inform users' energy know-how, to promote pro-environmental social norms, and to facilitate users in their day-to-day life to take energy-friendly actions together with online communities.

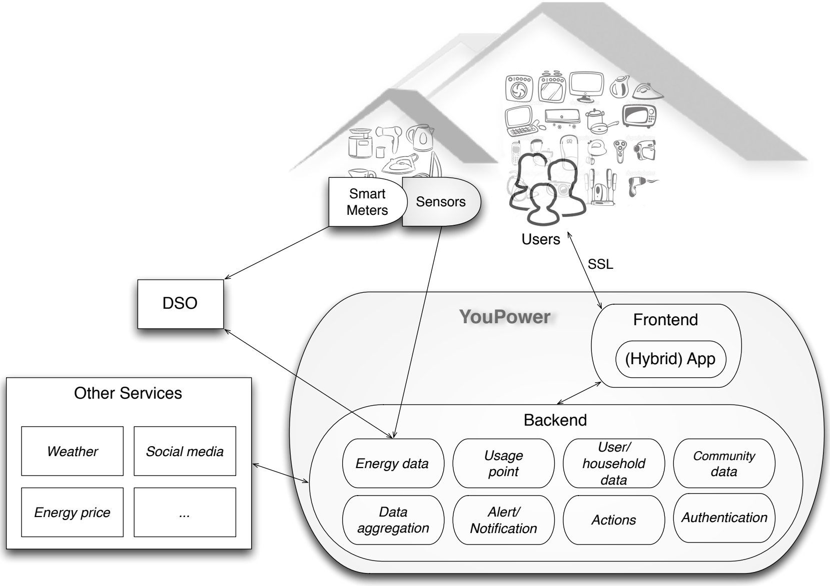
X The idea of linking smart grids with (online) *Social Network*s (SNs) as a joint R&D topic has recently caught much attention in media (Boslet, 2010; Chima, 2011; Erickson, 2012; Fang et al., 2013). There are many research efforts on either topics, but research on combining SNs with smart grids has just started. A number of recent works propose frameworks or approaches that interconnect smart meters (or smart homes) as SNs for energy management and sharing (Ciuciu et al., 2012; Steinheimer et al., 2012). In addition, Silva et al. (Silva et al., 2012) conducted surveys to understand user needs for energy services including SN services. Several frameworks or simulation models for demand side management and value-added web services with SN aspects have been developed (Chatzidimitriou et al., 2013; De Haan et al., 2011; Lei et al., 2012). Others have used simulation models to demonstrate the feasibility of social coordination in supply and demand (Skopik, 2014; Worm et al., 2013). Our research interest expands on the related work in that it focuses on smart grid user communities. The research is performed within the framework of the EU FP7 CIVIS project (`www.civisproject.eu`).

Project Context

2 STATE OF THE ART

Prior to designing YouPower, we review the existing studies with social smart grid platforms and summarize the lessons learned from those studies. Combining such lessons with findings from the literature on pro-environmental behavior change we compile a set of design guidelines with successful strategies and potential barriers for social energy platforms. For instance, a repeatedly reported issue with such platforms is a lack of long term user engagement (Edward and Jones, 2015). We adopt iterative, open and lean co-design process (Følstad, 2008; Klein, 2013) that is suggested as a promising approach to avoid this issue (Schwartz et al., 2014).

Existing social energy platforms. Weiss et al. (Weiss et al., 2012) developed a smartphone community platform, PowerPedia. The platform works in connection with smart meters and enables users to identify, upload and compare their appliance-level consumption data. The test users rated favorably



DSO (Distribution System Operators), SSL (Secure Sockets Layer)

Figure 1: YouPower system overview

social comparison features and appliance level statistics. Community Monitor (Dillahunt and Mankoff, 2014) featured leaderboard, message board and shared actions (”ways to save”). The findings from the 4-10 months trial revealed the importance of environmental and social context for social energy apps. For instance, the existence of common spaces for community members to interact and knowledge of other users supported the app use. Petkov et al. (Petkov et al., 2011) investigated comparative consumption feedback. Their findings confirm the importance of comparison to the similar users. However, if the competition features are included, then the users preferred to compete with the people whom they actually know, such as friends.

Design ideas and guidelines. The literature review suggests that the most successful behavior change interventions combine several different strategies (Gardner and Stern, 1996; Ockwell et al., 2009). However, a special care must be taken to avoid mixed messages (Knowles et al., 2014), especially when combining intrinsic and extrinsic motivations (Delmas et al., 2013). Additionally, the literature agrees that there is no a silver-bullet type of a solution and that we need interventions carefully *attending to the context* (Hargreaves et al., 2013; Dillahunt and Mankoff, 2014).

Most of the solutions involve some type of *consumption feedback*, such as historical or real-time (individual or group). Introduction of descriptive or injunctive *social norms* through comparative feedback has proven effective (Allcott, 2011; Cialdini, 2001; Petkov et al., 2011). Additionally, Strengers (Strengers, 2011) suggests combining feedback with *practical recommendations (tips)* that lead to new practices which challenge taken-for-granted notions of normality. Several studies (Abrahamse et al., 2005; Delmas et al., 2013) report tailored energy advice to a specific household and personalized information to be the most effective strategy. Another effective strategy that applies social dimension is *public commitment* (Abrahamse et al., 2005), a procedure in which people are binding to a certain behavior. One suggestion to increase the effectiveness is to *target organisations, companies and policy makers* (Hasselqvist et al., 2015; Brynjarsdottir et al., 2012) in addition to individuals. Next, we describe how each of the strategies above is incorporated into the design of YouPower (for the full set of our design guidelines, refer to CIVIS D3.2.).

X Considering the recommendation to attend to the intervention context and the analytical frames above, we chose a set of platform features and translated those into three self-contained and composable parts so that each part will support different CIVIS use-cases and the specific socio-economic contexts in Stockholm and Trentino. The three parts included in the CIVIS (front-end) application (hereinafter abbreviated as CIVIS app) are:

The Energy Data Visualization part of YouPower incorporates both individual and group (household and community) feedback. The community feedback informs about a collective effort and might enhance the feeling of group efficacy (Bandura, 1997). In YouPower, the special attention is given to the household context, since bringing *family values into discussion* and establishing *shared commitments and responsibilities* is reported to be effective (Huizenga et al., 2015). Additionally, the BRF part of the app applies social norms through comparison between the housing cooperatives. The BRF part also involves energy managers, who have the power to significantly influence the practices related to energy use. The Action Suggestions part not only teaches users about sustainable energy practices, but also applies public commitment strategy through making visible the actions that the user takes.

With peer review results and users' feedback on the design, adaptations and changes are made to suit user needs and to achieve the CIVIS research goal. In general, the application aims to enhance users' energy know-how through action suggestions that are implementable in everyday life, engage users in energy communities with understandable and actionable information and feedback, and facilitate community interaction and self-teaching by means of group discussions.

Given the time and resource constraints, the app can not be developed all-in-one cross-platform (for phones, tablets and computers). We chose to design the front-end as a mobile app. This means that the app design has layouts and user interactions that suit (small) phone screens. Western Europe has a large mobile phone internet user base[1]. Many surveys show that mobile apps have advantages such as creating deeper user engagement, easy sharing, among others[2]. This makes mobile app a good choice given the goal of the CIVIS platform. Once developed, mobile apps can also be more easily transformed to web browser versions, while the reverse is more difficult. The back-end of the CIVIS platform will remain mostly the same independent of the front-end alternatives.

[1]Between 2013 and 2017, the penetration rate of mobile phone internet users among mobile phone users will rise from 49.0% to 77.8%. See more at: `http://www.emarketer.com/Article/Nearly-Half-of-Western-Europeans-Will-Use-Mobile-Web-This-Year/1010510\#sthash.AaVfsqIU.dpuf`

[2]`https://infomedia.com/blog/the-advantages-of-mobile-apps/`, `https://econsultancy.com/blog/62326-85-of-consumers-favour-apps-over-mobile-websites/`

3 DESIGN CONCEPT

3.1 Action Suggestions

This part of YouPower (see screenshots in Figure 2) aims to provide users easy access to practical and inexpensive suggestions (or tips) to (1) increase energy awareness, (2) inform energy know-how, and to (3) shape their long-term behaviors related to household energy consumption. We collected about 50 suggestions (`https://goo.gl/R11QdZ`) from credible sources such as national and international energy agencies and associations. There are routine actions such as "don't keep hot water flowing when you wash your dishes by hand", regular actions such as "defrost your fridge in x days", and one time actions such as "install a programmable thermostat". Each action is accompanied with a short explanation that mainly focuses on intrinsic values to target long-term sustainable behaviors, the estimated impact and entailed effort (on a scale of 1 to 5), and the information about how many users are taking the action.

Users can choose to take a few actions at a time and are suggested with a new action when one is completed. Some suggestions can be triggered by time, e.g., "defrost your fridge in x days." In such cases, the app reminds the users of the pending actions they are interested in. When an action is completed, the user is awarded with points (displayed as *Leaves*) associated to the effort and impact level of that action. A user may also choose to abandon or reschedule an accepted action. Upon action completion and cancellation, a user is asked to give feedback. The user may "like" and "share" an action, rate the effort level of the action and give comments.

Engagement in Household and Communities To engage each member in a household, the app allows a user to add members (who are also YouPower users) to his/her household. A user can see the actions of household members, and add their actions to his/her own action list. A user can also join communities and participate in discussions to exchange their ideas and share experiences. The top actions (the ones with most participants) in a community are displayed to members to introduce social norms.

Personalization and Localization A user has a personal profile and a household profile. We allow a user to customize the display name, preferred language (English, Italian or Swedish), and to provide information about the household composition, home type and size, major appliances, etc. The information

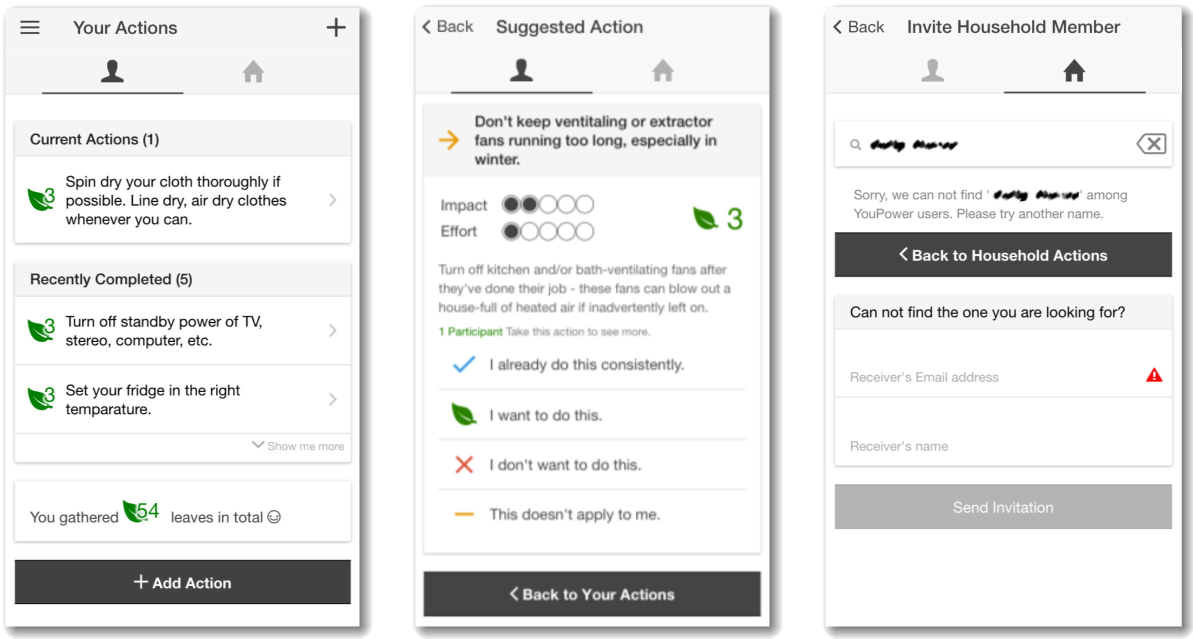


Figure 2: Action suggestion part of YouPower

is useful for personalized action suggestions, the comparison of similar households and individuals, and can be used for research purposes. A user (at the test sites) can link YouPower to the household's (DSO and sensors) energy data if an data account is provided. In such cases, the app customizes its content to a user's test site: housing cooperatives content for the Swedish site and load-shifting content for the Italian site. They are discussed in the next two subsections.

Design Evaluation The design was evaluated by peer reviews, a study with 24 participants in an environmentally-oriented event in Helsinki (`https://oscedays.org/helsinki/`), and a workshop with nine participants in the Italian test site. In general, people liked the idea of receiving action suggestions. They like to see the impact of their actions and asked for easy to perform actions. The majority was interested in collaborative community actions, e.g., to save together and to donate for a common goal. Very few had interest in competition. Many expressed the opinion that monetary savings are only somewhat important to them. They were also skeptical about how much money they can actually save. They instead showed interest to learn about energy saving strategies as they are driven by more intrinsic motives. Some participants think that the others (in their neighborhood or city) do not put the same effort in energy conservation as themselves do. The YouPower approach to display other people's actions may have the potential to motivate people seeing the others' efforts.

Some suggested that for those who do not have or are not comfortable with smart-phones, the app should be made available through a browser.

3.2 Housing Cooperatives

This part of YouPower (see a screenshot in Figure 3) is considered for households in the Stockholm test site. In Sweden, each apartment or house owner is a member of a housing cooperative that owns the property and annually elects a board that is in charge of the finances and maintenance of the property including making energy related decisions. Such a housing ownership concept exists in a number of EU and non-EU countries. Three main categories of features are designed for this part of YouPower: energy information about a user's own housing cooperative, energy information about other housing cooperatives, and support for communication between energy managers. Expected primary users are energy managers and board members of housing cooperatives. Secondary users are ordinary cooperative members.

Housing cooperative energy information includes comparative energy performance and the cooperative's monthly and yearly energy use, divided into heating (including hot water) and facilities electricity. Energy actions that have been taken are listed in relation with energy consumptions. A user can see when different actions, such as energy information, optimisation or investments, were previously taken and see more details about the actions. By comparing the en-

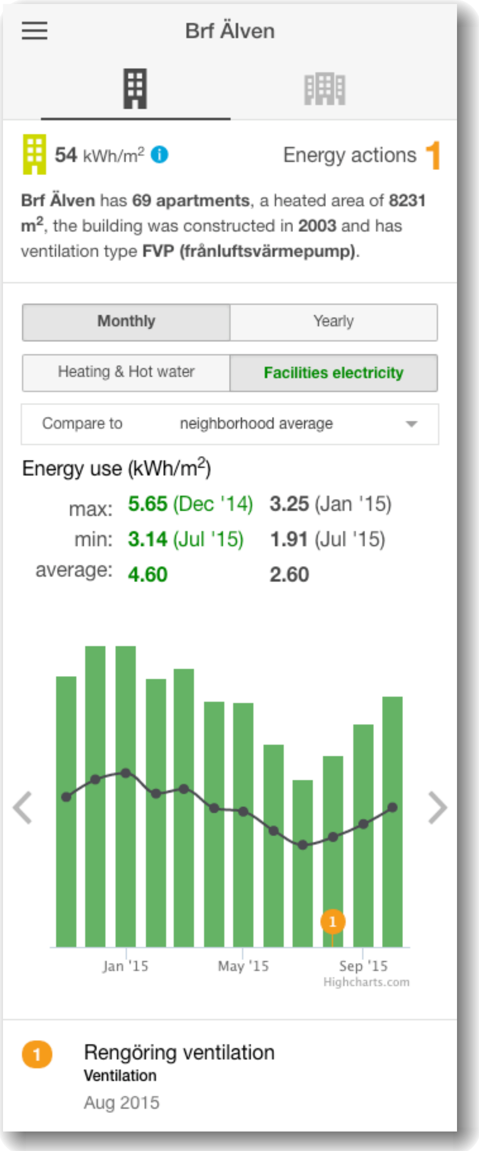


Figure 3: Housing cooperatives part of YouPower

ergy use with previous periods, the user can also see the impact of the actions. In the same way that the users can view information about their own cooperatives, they can also see the energy performance and energy actions taken by other cooperatives. This allows energy managers and others who are interested to e.g. explore the effect of a neighbouring cooperative's actions on their energy use and read about how they carried out an investment and which contractor was used. To further support collaboration and knowledge exchange between housing cooperatives, there is a discussion group dedicated for energy managers. Within the group they have the possibility of creating discussion topics of their interests. In this way, the discussion of the occasional meetings with the local energy network can be extended to continue online.

Design Evaluation The design was evaluated with three energy managers and the feedback was incorporated in the design improvement of the application. The energy managers would primarily want to use the app to find housing cooperatives with similar challenges and see what actions they had taken. They also thought the app would be helpful for deciding which companies can be trusted based on what other housing cooperatives had done and what the effects were on the energy use. The energy managers doubted that other members in their cooperatives would be very interested in following the cooperative's energy use, but they thought the app might be useful for engaging members in specific questions.

3.3 Energy Data

This part of YouPower (see screenshots in Figure 4) is considered for households in the Italian test site. The main focus is on leveraging load elasticity to maximize self-consumption of locally-installed Renewable Energy Sources (RESs); that is to support the shift of electrical consumption loads to match production peaks. A dynamic time-of-usage signal in combination with a scheme for energy donations is designed to assist this shift. Moreover, in order to make users aware of their consumption patterns, three different levels of energy consumption data are displayed in the app: household, appliances and community.

At the household level, the current and historical consumptions are displayed. For users with production from renewable sources – many households from the two Trentino test sites have roof-installed PV panels – the app compares production and consumption levels with the aim to raise awareness of different prosumption patterns. For users with installed smart plugs, the app visualizes consumption patterns at the single appliance level. This is meant to enable users to gain a deeper understanding of the relationship between their daily actions and the resulting energy consumption. At the community level, aggregated data is displayed about the energy balance of a community, (understood as the participants' aggregate consumptions done between consumption under green and red signals) -¿ "this is not understandable".

Dynamic Time-of-Use Signals A model (?) is designed to predict the level of production from renewables in the subsequent 72 hours. It is used to generate time-of-use signals that are sent to users. The linear prediction model uses solar radiation data from

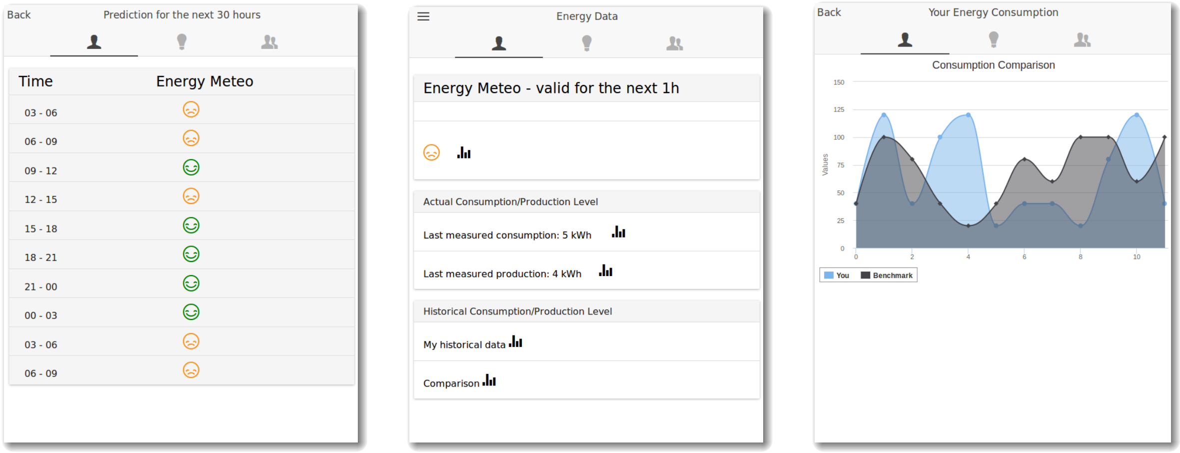


Figure 4: Energy data part of YouPower

both public and private sources[3] and historical data about the production of renewable plants provided by local energy consortia. Estimating consumption patterns based on historical data, a matching engine is designed to forecast whether there will be surplus of local productions. If so, a favorable price is offered to users as an incentive for them to move flexible loads (e.g., dishwater and washing machine) to the perspective time intervals. In the app, the time-of-use signals are represented by green and red face emoticons in order to identify, respectively, when users can consume and when not. Signals are forecasted for the following 72 hours, divided into three-hour intervals.

Energy Donation A user's contribution towards a better community energy load balance can bring about economic benefits for the electric consortia. Indeed, in both Trento test sites, local generations from RESs can cover the total consumptions at the aggregated yearly level. Yet, there are timing mismatch so that in order to serve demand peaks the consortia have to buy electricity from the national energy grid, while, at other times, local production exceeds demand, so that exceeding energy is sold. From an economic point of view, such transactions with the energy market are unfavorable, because electricity surpluses are sold at a price that is lower than the national retail market price. At the same time, purchase of electricity from energy market is paid at higher price. The electrical consortia foresee benefits, in economic and infrastructural terms, from leveraging load shifts and are therefore willing to support an energy donation programme. Indeed, users in the Trento test sites are part of such a donation programme, which is organized as participatory budgeting process, and from which they can opt-out. KwH consumed during peak of production (*i.e.* green face emoticon) contribute to the hoarding of collective KwH budget to be allocated to a beneficiary at the end of CIVIS trial period. In each test site, participants are allowed to submit proposals, in form of a simple and concrete project ideas, in order to be awarded as final beneficiary of the hoarded KwH budget. The app gives a description of the budgeting programme and provides information about the submitted proposals, so that users can be aware of what kind of beneficiary could benefit from the collective efforts. Furthermore, a simple chart shows how many KwH have been consumed in the green and red time zones.

Design Evaluation The design of the Energy Data part has been constructed and validated iteratively with users in Trento test sites. A preliminary inquiry of users' awareness about own energy behaviors and about energy as a collective matter was done through two focus groups. Later, two scenario-based workshops allowed to identify the main users' requirements for supporting the implementation of a load shifting intervention. Finally, two additional workshops were used to validate the proposed ideas, in terms of app's main functionalities, and to produce basic paper-based mock-ups, which CIVIS team used for defining the wire-frame for this part of YouPower. What emerged clearly from the focus groups is that participants share a good sense of energy as a deeply local and collective matter, which is mostly due to the membership-based and cooperative nature of the electrical consortia. They highlighted the relevance of educating people about energy related matters at

[3] Meteotrentino `http://www.meteotrentino.it`, OpenWeatherMap `http://openweathermap.org`, Fondazione Edmund Mach `http://www.fmach.it` and US National Weather Service `http://nomads.ncep.noaa.gov`).

different levels: from education for the youngest generations in public schools to concrete tools for raising awareness about personal energy behaviors. More concretely, visualization of own consumption (and, for prosumers, production) profiles was considered as a primary and paramount requisite for attempting to shift loads. A predictive system emerged as another cornerstone for enabling participants' flexibility to plan their energy-related behaviors and pursue load shifts. However, comparisons and means for benchmarking consumptions also emerged as highly desirable features for placing people understanding of own energy behaviors into a broader context. The direction towards the participatory budget process for allocating bonus KwH emerged from participants' desire to have a transparent and participated process.

4 MANUSCRIPT PREPARATION

Group 2. Additionally, you may wish to copy and edit the following 3 example files:

- `example.bib`
- `example.tex`
- `scitepress.eps`

4.0.1 Tables

Table 1: This caption has more than one line so it has to be justified.

Example column 1	Example column 2
Example text 1	Example text 2

4.0.2 Equations

Equations should be placed on a separate line, numbered and centered.
The numbers accorded to equations should appear in consecutive order inside each section or within the contribution, with the number enclosed in brackets and justified to the right, starting with the number 1.

Example:

$$a = b + c \tag{1}$$

4.0.3 Program Code

Program listing or program commands in text should be set in typewriter form such as Courier New.

Example of a Computer Program in Pascal:

```
Begin
    Writeln('Hello World!!');
End.
```

5 CONCLUSIONS

ACKNOWLEDGEMENTS

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