D3.3 Final Field Tested Integrated Energy System

Workpackage 3

Responsible Unit: TU Delft

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Executive Summary

This report summarizes

1 Introduction

1.1 Overview

D3.2) Final field tested Integrated Energy System: Output of T3.1-5; Based on information provided by the deployment of deliverable 3.2 the software is further refined to provide energy services and community management (open source).

In the third year of Work Package 3 (WP3), we continued the design and development of the software platform YouPower[1] based on the results reported in D3.2. In this report, the final results are summarized as a whole for readability and usefulness. The refinement and improvement made in the third year are highlighted when necessary and possible. The functionalities of the platform reported are deployed at Stockholm and/or Trento test sites respectively according to the local context. The YouPower software is open source under the Apache v.2 License[2]. It has an online repository at GitHub[3]. The backend API documentation is aslo available online[4].

1.2 Aims and Scope

As stated in D3.1, past research has typically regarded grid users as individual entities driven by economic considerations, contributing individually to achieve energy goals (e.g. Barbieri et al., 2013; Buoro et al., 2012; Martínez-Lera et al., 2013). A novel research goal of CIVIS is that our research attention is oriented to the potentials and challenges of users' collective action, pro-social values and sense of community. We deem collective human behaviour critical, because it is *both* a source of and a solution to the problem of climate change (Masson and Fritsche, 2014).

To this end, we aim to explore the potential and challenges of supporting social participation, awareness and engagement by means of ICT in the smart grids to achieve sustainable energy goals such as consumption reduction and load shifting. In D3.1, we reasoned that an energy software platform that includes features of Social Network (SN) platforms can be used to form energy prosumer communities. On such a *Social Smart Grid Platform* (SSGP), users can share energy-specific interests and values, exchange experiences, compare energy consumption, and receive actionable information and feedback. Moreover, we as researchers can use this platform as a communication channel to promote the aforementioned goals. The platform is also a research instrument to observe users' activities (including their self-exposed energy behaviors), responses, and possible outcomes in energy consumption and social impact. The data collected through the platform will be analyzed in the third year of the CIVIS project.
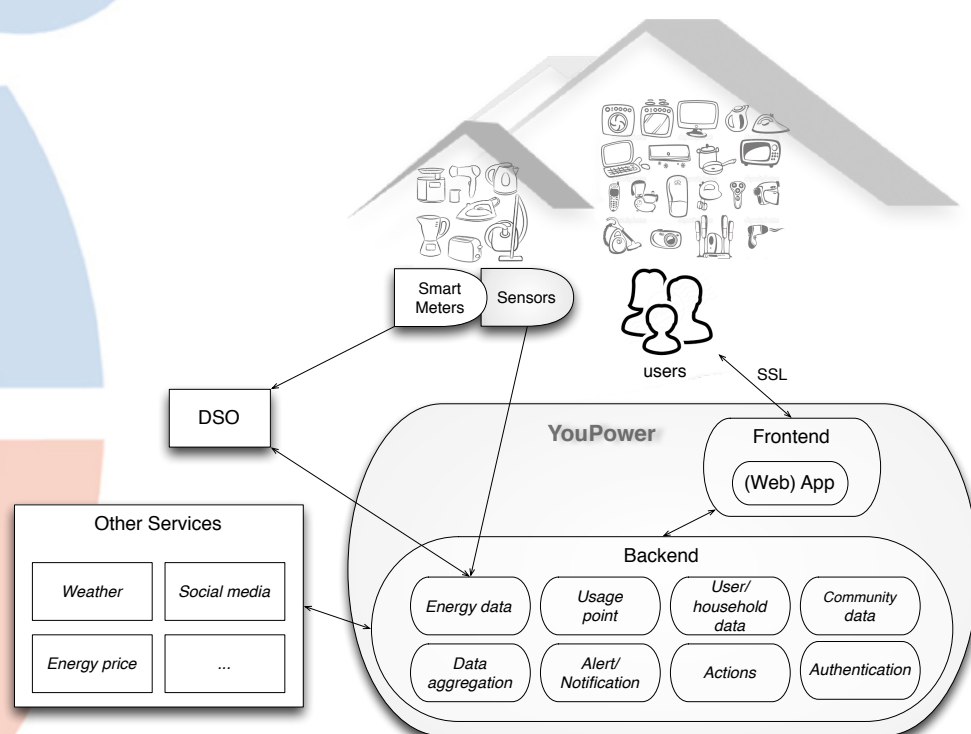
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[1] http://civis.tbm.tudelft.nl/
[2] https://github.com/CIVIS-project/YouPower/blob/master/LICENSE
[3] https://github.com/CIVIS-project/YouPower/
[4] http://civis.tbm.tudelft.nl/apidoc/

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

Figure 1: CIVIS platform overview

Figure 1 gives an overview of the CIVIS platform. The scope of WP3 D3.2 is indicated by the dashed circle. The CIVIS platform is composed of services developed by WP3 and WP4 (the CIVIS back-end), and an application (the CIVIS front-end) that interacts directly with users. Briefly, WP4 focuses on the system level ICT services that deal with energy data that is collected by smart meters and sensors installed at households in the Swedish and Italian test sites (see D4.2 for more details). WP3 focuses on the front-end application and the social level ICT services that deal with user, household and community data. Unless otherwise specified, this report discusses the design and development of the WP3 part of the CIVIS platform which is called *YouPower*[5]. The name suggests a non-solipsistic state of mind — by using "You" (Crumlish and Malone, 2009) — in facing and tackling energy-related issues, with overtones of user empowerment.

1.3   Design and Development Process: the Continuation

An important research question to be investigated in WP3's second year's activities is: what is a good design of a SSGP that can be potentially successful given the goals and context stated in 1.1 and 1.2. We have followed an adaptive agile development process with iterative rapid prototyping (Leffingwell, 2011). This is a discovery-based approach where users are actively involved in reviewing and giving feedback to the prototype design from the onset and throughout the process.

During the period of Oct. – Nov. 2014, an initial set of CIVIS platform features[6] was collected collaboratively using Google Docs. A CIVIS design workshop took place at TU Delft (see D1.2). In several rounds, CIVIS partners proposed candidate features that are potentially useful to the CIVIS plarform based on their knowledge and expertise, informed by user needs and the state-of-the-art.

These features were organized into categories and were used as a basis for further discussion in the Telcos during Dec. 2014 – Jan. 2015 among CIVIS partners. As a result, a list of features was selected and prioritized by usefulness, feasibility and practicality.

In Feb. 2015 we began to make wireframe mock-ups[7] of the CIVIS front-end application. The mock-ups served as visual guides that can be more easily communicated to general users compared to traditional software requirement and design documents. Since then, we continually modified the design (mock-ups) based on the feedback and advices from colleagues, peers and focus group meetings (see D1.2).

The prototyping was started in May 2015[8]; the back-end development followed one month later. They evolved into the current version of YouPower, as a proof of concept for a SSGP. At

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[5]The CIVIS front-end application used to be called EnergyUP. The old name may be found in some old documents and/or mock-ups.

[6]A feature of a system or a product is a high-level expression of a desired system behavior (Leffingwell and Widrig, 2000).

[7]A shortened list of YouPower mock-ups can be found at `http://civis.tbm.tudelft.nl/mockups/`.

[8]The latest version of the prototype can be found at `http://civis.tbm.tudelft.nl/frontend.html`.

the moment of writing this report, YouPower is still in development. It is planned to be deployed at the Stockholm and Trentino test sites by Oct. 2015. The CIVIS server at TU Delft hosts the latest deployment of YouPower[9].

The rest of this report discusses the design and development of YouPower. During the design and development process, we have paid particular attention to quick responses to changes, and adaptive development. In this report, however, limited by time and space, we will skip the intermediate steps and only discuss the end results. In Section 2, we first discuss the analytical framework and guidelines we adopted for the CIVIS platform design, and then present the design concept of the CIVIS platform. In Section 3, we give an overview about the technologies and platforms we choose to use for the CIVIS prototype development. The relevant references and resources are added for further information. In Section 4, we review the WP3 tasks and discuss a number of open issues.

2 CIVIS Platform Design

2.1 Design Guidelines

2.2 CIVIS Platform Design

The Improvement and Finalization

2.2.1 Action Suggestions

2.2.2 Housing Cooperatives

Hammarby Sjöstad, Stockholm Test Site

2.2.3 Energy Data Visualization and Comparison (need another title probably)

Trento test site

The side navigation (nav) is composed of six items, among which the "Energy Data" and "Housing Cooperatives" are activated respectively when a user authenticated his/her household's account for energy data (production is only for the Italian case) or when a user is a member of a housing cooperative (the Swedish case). Each tab item is associated with at least one view. Figure 2 shows an example: the "Action List" view of "Your Actions" tab with a closed (left) and an open (right) side navigation drawer.

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[9]The lastest version (a web-version designed for mobile screens) can be found at `http://civis.tbm.tudelft.nl/`. The CIVIS repository at GitHub `https://github.com/CIVIS-project/YouPower/` hosts the source code and manages version control.

Table 2: YouPower app navigation structure

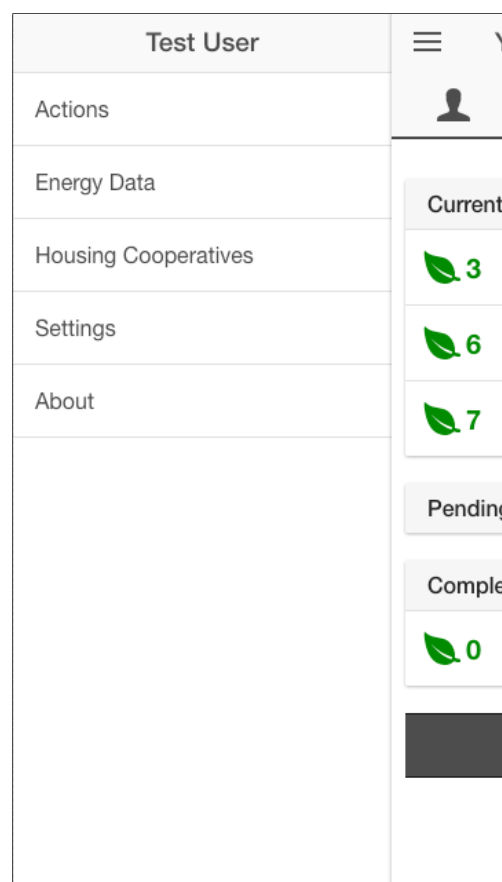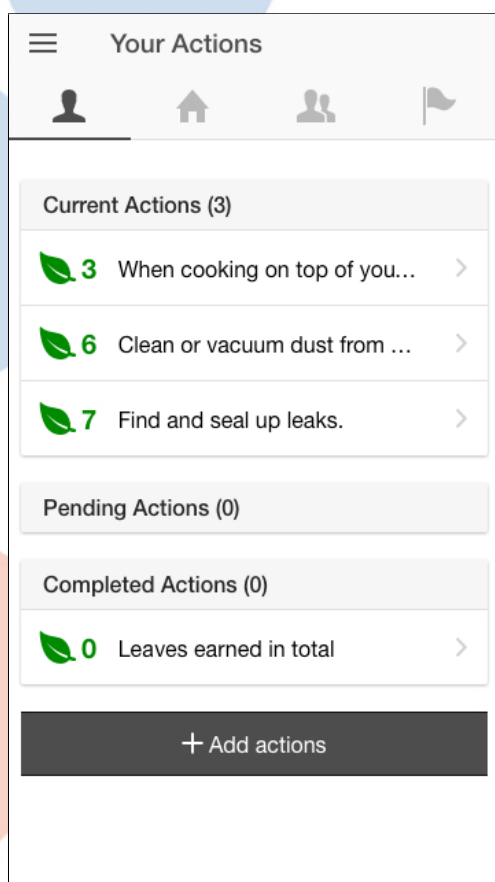| Side Nav Items	Tab Items	Views
Actions	Your Actions	Action List, Action Suggestion, Action Details, Action Completed Form, Action Abandoned Form, etc.
	Household Actions	Member List, Action List, etc.
	Community Actions	Community List, Top Action List, Discussions, etc.
	Achievements	Achievement List (unlocked/locked), etc.
Energy Data	Household Level	Current Tarif (Trentino only), Current Consumption, Current Production, Historical Production/Consumption Patterns, Forecasted Tarifs (Trentino only)
	Appliance Level	Consumption Patterns (for each monitored appliance)
	Community Level	Total Community Consumption (last month), Total Community Production (last month), Community Energy Balance, Comparison with Benchmark
Housing Cooperatives	Your Cooperative	Action List, Consumption per Category, Discussions, etc.
	Cooperatives in Neighborhood	Action Map, Action List, Discussions, etc.
Donation (Trentino only)	n/a	Campaign Information, Campaign Status
Settings	Preferences	Form
	Personal Profile	Form
	Household Profile	Form, Eenergy Data Account
About	Q&A	Q&A List
	Help & Feedback	Contact, Form
	Version Update	Version Info

Figure 2: "Your Actions" tab – "Action List" view (left); with an open side nav drawer (right)
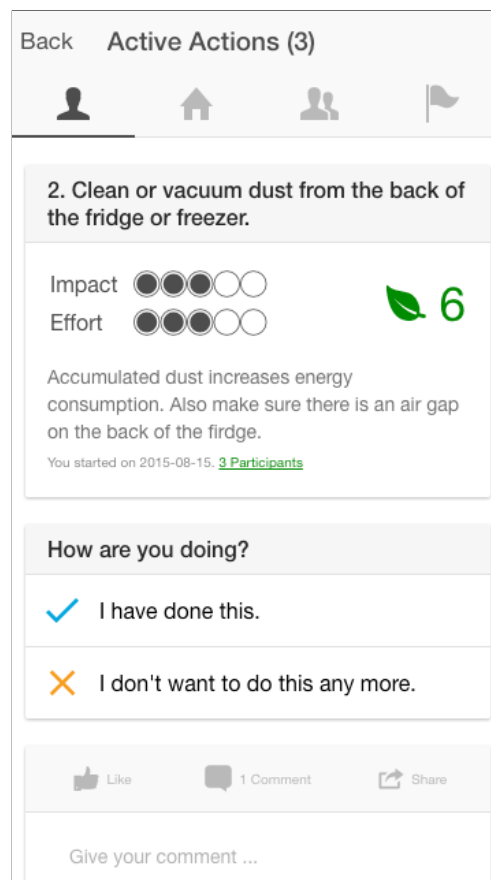
Figure 3: "Your Actions" tab – "Action Details" view

The "Action List" is the index view of "Your Actions" tab. It is also the default view after user login. In this case, when the user presses on one of the "Current Actions", the app navigates to the "Action Details" view. Figure 3 gives an example.

3 CIVIS Platform Development

The CIVIS platform was under development (implementation) since May 2015 (Huang et al., 2015). The development continued in the second year's WP3 activities. At the time of written this deliverable, the development is completed with some minor updates took place in the past month. The JavaScript (JS) programming language[10] is used for development at both front- and back-ends. The platforms and technologies mentioned in this section are all free and open source.

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[10]http://www.crockford.com/javascript/javascript.html

3.1   CIVIS Front-End as a Hybrid Application

The CIVIS front-end (YouPower) is developed as a hybrid (cross-platform) mobile application using Ionic[11], an HTML5 front-end development framework built with SASS[12] and optimized for AngularJS[13] (a.k.a Angular). The Ionic framework comes with native-styled mobile UI elements and layouts, and handles the look and feel and the UI interactions the app needs in order to be compelling[14].

The energy data visualizations are built using the HighCharts library[15], wrapped using the `highchart-ng` directives for Ionic[16].

Angular as a JavaScript framework provides directives (extensions of HTML attributes) and two-way data binding (binds input or output data of the view to a model) that simplify the app development with MVC architecture. The "Current Actions" in the "Action List", for example, are rendered with the following HTML code:

```
<div class="...">Current Actions ({{_.size(currentUser.actions.inProgress)}})</div>
<a class="..." ng-repeat="action in currentUser.actions.inProgress" ng-href="#/app/actions/active/{{$index}}">
   {{getActionPoints(action)}} {{action.name}}
</a>
```

where `currentUser.actions.inProgress` is a model of a list (`array`) of the user's actions (the data) that are dynamically loaded into the corresponding controller from the CIVIS back-end at runtime. The Angular directive `ng-repeat` then iterates through the list, takes each element as an `action`, and displays the data in the view. The function `getActionPoints(action)` is defined in the controller. It is a good example of two-way data binding where the value of `action` (the model) is passed on from the view to the controller, and the function returns the result form the controller to the view.

3.2   CIVIS Back-End

An early version of YouPower[17] has its back-end on Firebase[18] to have a quick set-up. For the same reason, the YouPower back-end development is first deployed on Heroku[19]. In July 2015, TU Delft finished preparing a virtual machine for CIVIS, so the WP3 back-end is currently hosted by a TU Delft server at http://civis.tbm.tudelft.nl. The CIVIS app back-end interacts with the IT platform developed in WP4, from which it fetches relevant data to

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[11]http://ionicframework.com/
[12]http://sass-lang.com/
[13]https://angularjs.org/
[14]http://ionicframework.com/docs/guide/
[15]http://www.highcharts.com/
[16]https://github.com/pablojim/highcharts-ng
[17]Branch   study-protoype   https://github.com/CIVIS-project/YouPower/tree/study-prototype, https://app.civisproject.eu/frontend.html
[18]https://youpower.firebaseio.com/
[19]https://www.heroku.com/

be used in the front-end. This is particularly relevant for visualization of energy consumption/production data, energy price data and donation programme data. The availability of such data through the WP4 platform represents therefore a pre-condition for the ability of the app to correctly visualize such information.

The YouPower back-end is developed using the Node.js[20] platform, a well-known JS based open source runtime environment for server-side applications. The platform is easily extensible and has a repository of libraries that support fast web development. MongoDB[21] is used as the back-end database. It is document-oriented, and has flexible data schema and expressive query language. A list of the data models at the back-end can be found at `https://github.com/CIVIS-project/YouPower/tree/master/backend/models`. Figure 4 shows the data model schema. The noteworthy Node.js libraries we use for the back-end development are as follows:

- Async.js[22], which makes managing and combining asynchronous tasks easier.

- Express.js[23], a Node.js application server framework we use as a basis for the REST API.

- Mocha[24], a JavaScript unit test framework.

- Mongoose[25], a MongoDB driver for Node.js. It provides a schema-based solution to model data.

- Passport.js[26], for handling authentication of REST API requests for Node.js, both local (username password) and Facebook.

- Ionic Push[27], for sending dynamic push notifications.

- APIDOC script[28], for inline documentation for the REST API.

The YouPower back-end REST API documentation can be found at `http://civis.tbm.tudelft.nl/apidoc/`.

4 WP3 Tasks: Summary of Contributions

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[20]`https://nodejs.org/`
[21]`https://mongodb.org/`
[22]`https://github.com/caolan/async`
[23]`http://expressjs.com/`
[24]`https://mochajs.org/`
[25]`http://mongoosejs.com/`
[26]`http://passportjs.org/`
[27]`https://apps.ionic.io/landing/push`
[28]`http://apidocjs.com/`
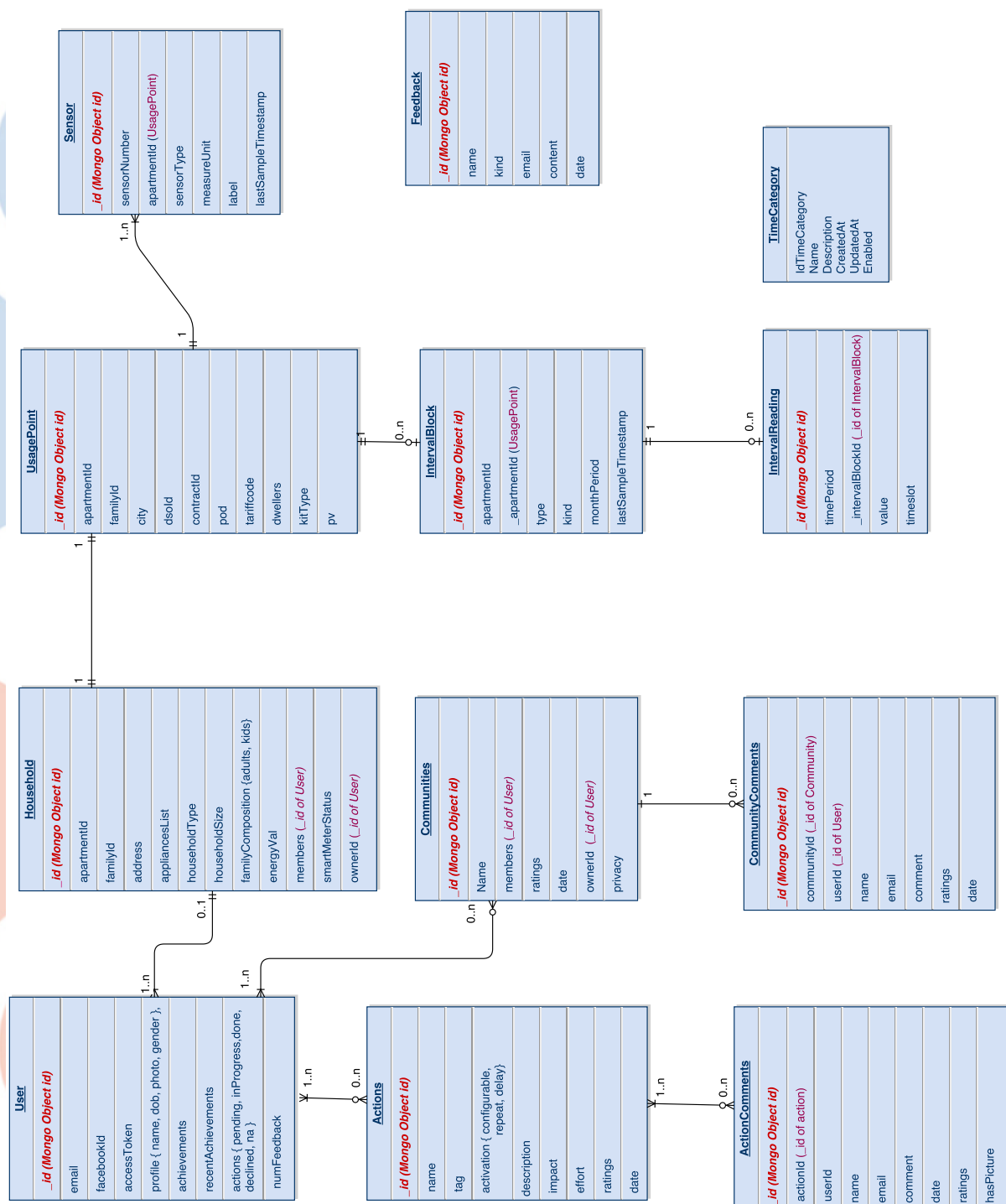
Figure 4: YouPower back-end data model schema

References

Barbieri, E., Y. Dai, M. Morini, M. Pinelli, P. Spina, P. Sun, and R. Wang (2013). Optimal sizing of a multi-source energy plant for power heat and cooling generation. Applied Thermal Engineering. In Press.

Buoro, D., M. Casisi, P. Pinamonti, and M. Reini (2012). Optimal synthesis and operation of advanced energy supply systems for standard and domotic home. Energy Conversion and Management 60, 96–105.

Crumlish, C. and E. Malone (2009). Designing Social Interfaces: Principles, Patterns, and Practices for Improving the User Experience. O'Reilly Media.

Huang, Y., D. Miorandi, H. Hasselqvist, M. Warnier, S. Scepanoic, and R. Eskola (2015). D3.2 intergrated energy system. Technical report, CIVIS Project.

Leffingwell, D. (2011). Agile Software Requirements: Lean Requirements Practices for Teams, Programs, and the Enterprise. Agile Software Development. Addison-Wesley Professional.

Leffingwell, D. and D. Widrig (2000). Managing Software Requirements: A Unified Approach. Addison-Wesley.

Martínez-Lera, S., J. Ballester, and J. Martínez-Lera (2013). Analysis and sizing of thermal energy storage in combined heating, cooling and power plants for buildings. Applied Energy 106, 127–142.

Masson, T. and I. Fritsche (2014). Adherence to climate change-related ingroup norms: Do dimensions of group identification matter? European Journal of Social Psychology 44(5), 455–465.