Deliverable D7.3

Final Evaluation report

Work Package 7

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Terms and Acronyms

BRF	Housing Association (Bostadsrättsförening in Swedish)
CEdiS	Electrical Consortium of Storo
CEIS	Industrial Electrical Consortium of Stenico
CPI	Category Performance Index
DOW	Description of Work
DSO	Distribution System Operator
DSS	Decision Support System
EE	Energy Efficiency
ESP	Energy Solidarity Project
HSW	Household Sanitary Water
ICT	Information and Communication Technology
PV	Photo Voltaic
SCPI	Sub-category Performance Index
SEF	Specific Emissions Factor
SH	Space heating
ToU	Time of Use
RES	Renewable Energy System
WP	Work Package

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Executive Summary

This report provides the final evaluation of the test sites based on the Work Package 7 (WP7) objectives, as laid out in the CIVIS Description of Work (DoW) notably:

- *To measure the reduction of energy consumption and of CO2 emissions through the introduction of the CIVIS ICT platform.*
- *To analyse the social and economic drivers for the success (or failure) of the measures. These will be determined by means of qualitative analysis.*

This deliverable presents the analysis of impact for the interventions carried out in the Italian and Swedish test sites at the end of the project. During the third year of the project, the CIVIS ICT platform, YouPower, was deployed in the test sites. The sensor deployment was completed in the test sites. In the Swedish test sites, the main focus of the interventions was on heating at housing association level in Hammarby Sjöstad and at household level in Fårdala. In the Italian sites ToU signal was introduced in order to facilitate demand side management and prosumer self-consumption.

Following the completion of intervention deployment and trial period, the results of the measures were analysed. Surveys and interviews were conducted in order to gain better understanding of user behaviours and motivation to change. In Hammarby Sjöstad, the housing association part of the trial achieved good results, with a continuation process already on going to expand the activities started with CIVIS. In Fårdala, heating control through MAX resulted in positive savings in heating demand during the trial period. In the Italian test sites, there was an increase in PV self-consumption and an overall reduction in electricity consumption. The ToU engagement was also more pronounced among the prosumers. The analysis of heating data also suggests positive impact.

Overall, the project was able to achieve successfully energy reduction in some of the use cases while engagement was lower in the others. Various socio-economic factors contributed to that. In general collective measures with high savings potential were more successful.

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1 Introduction

At the end of the three-years CIVIS project, the Deliverable 7.3 "Evaluation Report" describes and discusses the main results, based on the measurements collected in the different Pilot Sites.
The tested concepts and technologies, consisting in the interaction of the energy with the ICT and the social dimensions, are evaluated in their potentialities to influence the energy usage and the correlated CO_2 emissions, in so called "smart cities".

1.1 Work Package 7 and Deliverable Objectives

The main objective of WP7 is to test the effects, in terms of reduced energy use and reduced CO_2 emissions, of the technology proposed within the CIVIS project, by running extensive real-life evaluation tests on the two pilot sites. The following objectives are identified:

- To measure the impact on energy consumption and of CO_2 emissions through the introduction of the CIVIS ICT platform and other interventions. The energy use and CO_2 emissions will be determined from detailed measurements of energy supply (electricity, fuels, district heating/cooling) and/or energy use (electricity, sanitary hot water, heating).
- To analyse the social and economic drivers for the success (or failure) of the measures. These will be determined by means of qualitative analysis. The expected outcome of the measurement is also to suggest explanations for the results, namely, the main drivers for the energy and CO_2-emission performance of the pilot sites.

The deliverable 7.3 covers the tasks 7.3, 7.4 and 7.5 up to M36, dealing with the final results from the measurements as well as an analysis of the tested concepts and technologies for meeting reduction targets in terms of energy consumption and CO_2 emissions.

1.2 Target Audience

This report aims to provide an overview of the test sites to the different CIVIS stakeholders in order to support the project. The dissemination level of this report is public. The report helps in the understanding of the socio-technical aspects of the test sites and is useful for stakeholder within CIVIS as well as national and local actors in the energy context. Private

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entities with interest in energy efficiency can also find the report useful in understanding the systems in place on test site.

1.3 Report Overview and structure

The report has been structured in following way:

Chapter 1: provides and introduction to the objectives.

Chapter 2: covers the evaluation of Italian test sites. The impact of ToU signal, visualization of user data and impact of thermal energy use are presented.

Chapter 3: provides the impact of measures carried out in Swedish test site. The intervention with housing associations, household level visualization, introducing Smappee energy monitors and Max heating control system are presented.

Chapter 4: provides a summary of impact in test sites and concluding remarks.

1.4 Summary of Updates

In this revised version of the deliverable as per the observations in the Final review report CNECT/H4/PB/lb (2017) 270089 dated 17th January 2017. Below is a summary of the changes followed by reference to relevant chapters along with comments on the updates.

Ser. No.	Reviewers' comment	Relevant section	Page	Status/Comments
1.	It is very difficult to assess the quantitative impact of the social aspects (positive/neutral/negative) and related ICT on the e.g. energy usage. It was not only problem in short term of observation, but also in wrong methodology, makes unable to collect and compare reliable historical data, makes the users engagement relatively low and makes difficult	4	100	Addressed in the conclusion chapter

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	to compare the impact from engaged and non- engaged users and dwellings. The final, critical remarks about the quantitative influence of CÍVIS should be included in the D.7.3.			
2.	The part presenting the ToU results is not properly presented. The Figures are not described (axis, meaning of presented values and parameters). Each subsection ends with the „CEDIS percentage of withdrawal...” summary, but it is unable to assess the result. The D7.3 should present the results of „reduction/savings/consumption” measurements. The influence of CÍVIS should be distinguished. The presentation of ToU part doesn't give the base to draw the conclusions.	2.2, 2.3		Addressed. Axes to the ToU Figures have been added. The ToU part (chapter 2.2) presents quantitative results about electrical consumption shifting of CIVIS participants. CIVIS participants are divided in CEIS and CEDIS users, YouPower users and non-users, PV owners and non-owners. Only the YouPower users were exposed to the signals (green and red) produced by prediction of the local energy system balance (based on prediction of local production and prediction of local consumption). Chapter 2.3 describes quantitative results of electrical data analysis in Italian test sites (results of reduction/savings/consumption measurements).
3.	The analysis of measurement were marked in D7.3 as preliminary (page 15). Is it expected to obtain the non-preliminary measurements in future or the final evaluation can be based on preliminary results only?	1.1	15	Addressed.
4.	In Italy not all families were equipped with the sensors. What was the influence and role of families without sensors?	2	22-23	Addressed. Due to technical limitations some families participating in CIVIS project were not equipped with sensors (e.g. lack of internet connection, characteristic of the buildings that prevent the transmission of data). These families represent only a small number both in CEIS (18/68) and in CEDIS (4/33). Despite the lack of sensors these families have actively participated in the CIVIS project, they have been engaged in public events organized by the project,

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				and through participation in questionnaires. For these families the evaluation of CIVIS impact is only based on the analysis of the electricity consumption & production (and not on the analysis of the ToU signal and on the analysis of the heat demand).
5.	Why the number of engaged families that have the sensors installed is significantly greater that number of YouPower app users? Shouldn't it be a commitment in case of CÍVIS beneficiary (if e.g. families get the sensors for free?).	2	22-23	Addressed. In Italy several CIVIS families were composed by elderly people that were not used to interact with ICTs and software applications like YouPower. This is why several families that were part of CIVIS project and have smart meters were not able/interested in using YouPower. However, these families have been affected by CIVIS project using home displays and through participation in CIVIS social meetings.
6.	Page 20 -> (Error! Reference source not found.) on preliminary results only?	2	23	Addressed.
7.	The description of "Figure 3 YouPower users engagement for Italian users" (Page 20) is not sufficient. What are the following plots (it is not visible) It is lack of comment (especially on the individual increase in April). How is the result assessed?	2	23	Addressed. The description of Figure 3 is improved (adding also axis). It is now explain the increase in March/April (based on launch of YouPower app in Italy). These results show how "Trentino prosumption request" (ToU signal) is by far the most engaging feature.
8.	The plots in deliv. are not clear. The X and Y axis should always be specified. Nevertheless, it is unknown what is on Y axis on Fig. 10. What is TOT on Fig. 14 and 15? Total? On Fig. 50 the subsequent plots are not described.	2.2.5; 3.5	34-39; 83-85	Addressed. Axes to the Figure 10 and Figure 13 have been added. In Figure 11, 12, 14, 15 TOT is the total abbreviation and has been added to the description. Fig 50 and on have been described in text and captions.
9.	How the ToU related measurements were collected? Was it able to distinguish the CIV1S user form non inhabitants that were not involved in the project?			The evaluation of ToU signal in Italy is based on time distribution of low signals (in CEIS and in CEDIS) available through YouPower app and on withdrawal profiles of CEIS and CEDIS participants in CIVIS project available through CIVIS

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				smart meters. ToU evaluation compares, only between participants in CIVIS, users who have used YouPower app and those that did not. For privacy reasons it was not possible to use the data of inhabitants not involved in the project.
10.	If the ToU signals were available through YouPower app since March 2016, why the Figure 3 on page 20 presents the period since October?	2	23	Figure 3 includes the use of YouPower app both in Sweden and in Italy. In Sweden the YouPower app was introduce in November (in October we have only some test of the app by CIVIS developers)
11.	What the "withdrawal profile" means? It was used but not defined in the deliv.	2.2.5	34	Withdrawal profile refers to consumption from electrical grid. The definition has now been added.

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2 Italian Test site evaluation

In Italy a statistically significant number of users (for a total of 101 families) were involved in CIVIS project. They have tested the CIVIS energy ICT infrastructure and services for more than one year (from May 2015).

The involved families are part of two different communities of energy prosumers, namely CEIS[3] and CEdiS[4], located in the north of Italy (Province of Trento, Figure 1).

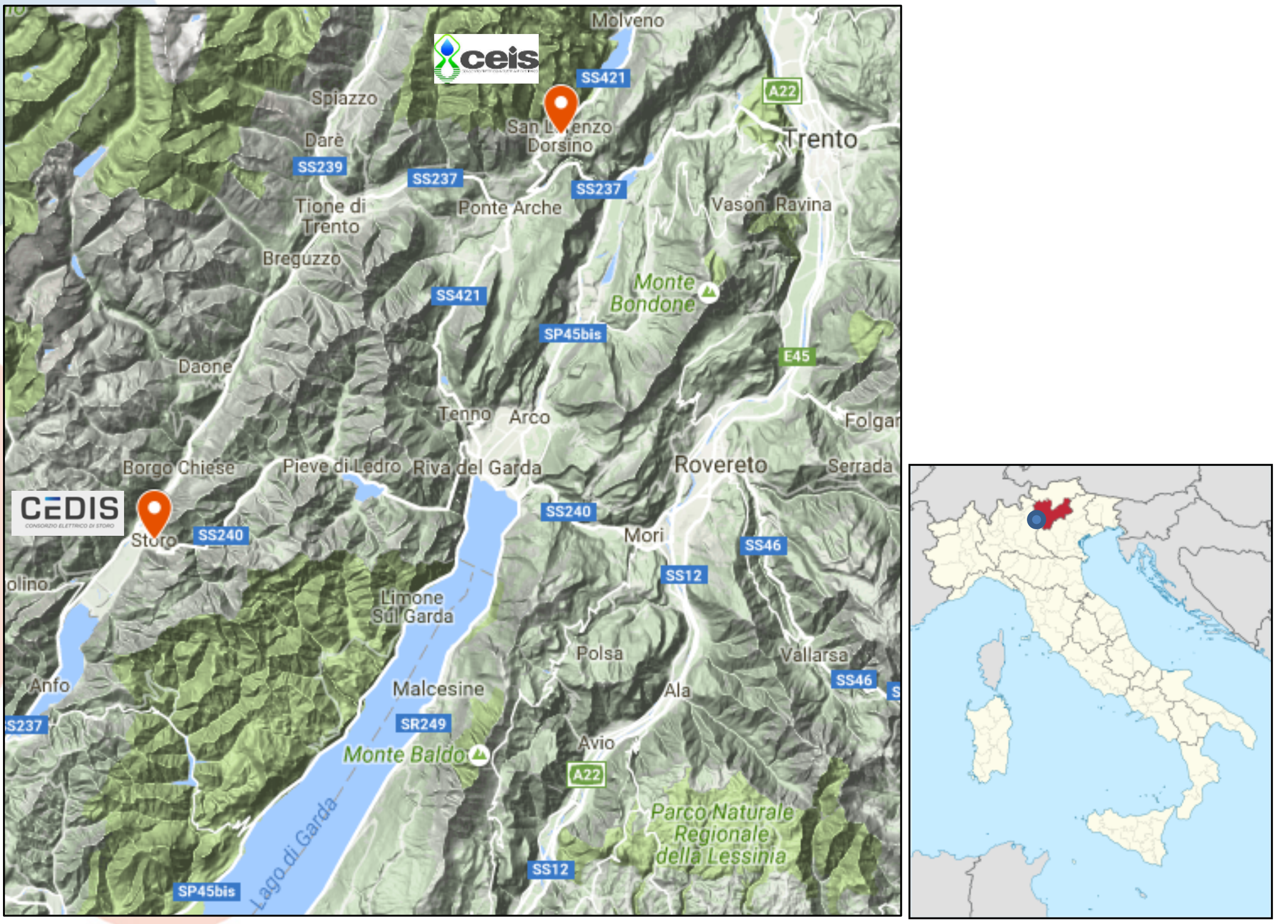

Figure 1 Location of the CIVIS Italian pilot sites

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[3] CEIS is the electrical DSO active in the area of San Lorenzo Dorsino

[4] CEdiS is the electrical DSO active in the area of Storo

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CIVIS interventions can be summarized in the use of ICT (smart metering, software applications) to increase energy awareness and stimulate an improvement of positive energy and environmental behaviours (consume less, consume better). In Italy a special attention has been paid to optimizing the use of local renewable energy sources (RES).

CIVIS actions comply with the indications of Article 9 and Article 10 of the EU Energy Efficiency Directive (2012/27/EU). In the Article 9 (Metering) Member States shall ensure that, "in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity, natural gas, district heating, district cooling and domestic hot water are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use". In the Article 10 (Billing information) Member States shall ensure that "final customers have the possibility of easy access to complementary information on historical consumption allowing detailed self-checks. Complementary information on historical consumption shall include: (a) cumulative data for at least the three previous years or the period since the start of the supply contract if this is shorter; (b) detailed data according to the time of use for any day, week, month and year".

Testing the smart metering technologies in a real environment, with a significant number of users and for a long enough time period, CIVIS project can provide useful evaluations about correlated social acceptability and potential energy savings.

The installations of CIVIS sensors (Figure 2) began in May 2015 and ended in November 2015, introducing smart metering of electrical consumption, PV production, outdoor temperature, indoor temperature. The YouPower software applications (active in Italy from 11/03/2016, Figure 3) include data visualization in real time, data comparison with historical data, tips, time of use signals (elaborated from 13/01/2016 and introduced in YouPower from 11/03/2016).

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Figure 2 Installation of CIVIS smart metering in the Italian pilot sites (1); Current Cost smart metering (2); YouPower App (3)

The Italian social participation in CIVIS is characterized by a total of 101 families, of which 68 in the CEIS area and 33 in the CEDIS area. Not all the involved families are equipped with smart meters (Table 1), due to technical limitations some families participating in the project were not equipped with sensors (e.g. lack of internet connection, characteristic of the buildings that prevent the transmission of data).

In CEIS, 50 sensors for total electricity consumption (from grid + from PV, if present), 20 sensors for PV electricity production and 50 sensors for building indoor temperature are installed. In CEDIS, 29 sensors for total electricity consumption, 9 for PV electricity production and 29 for building indoor temperature are installed. In addition, 2 outdoor temperature sensors are located in the CEIS area and other 2 in the CEDIS area.

Table 1 Number of involved families in Italy and installed smart sensors

	CEIS	CEDIS
Involved families	68	33
of which:		
Equipped with total electrical consumption sensors	50	29
Equipped with PV electrical production sensors	20	9
Equipped with building indoor temperature sensors	50	29

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In Italy the number of YouPower[5] registrations, at time of writing of this deliverable, since the Italian launch of the 11 March 2016, has reached the 32 units, of which 22 in CEIS (32 % of the involved families) and 10 in CEDIS (30 % of the involved families). Not all the participants were able or interested in using YouPower also due to the digital divide affecting several families, which are composed by elderly people that do not have enough technological skills.

Number of actions users have taken per action type show how "Trentino prosumption request" (ToU signals) is by far the most engaging feature, with an usage peak in April of about 5000 login/month (Figure 3).

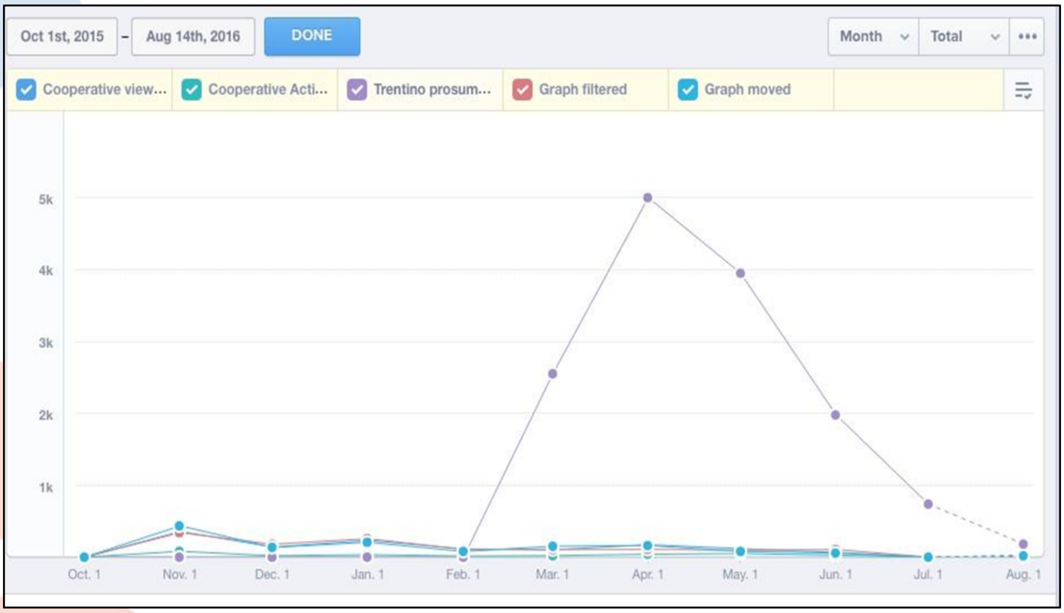

Figure 3 YouPower users engagement in Italy and in Sweden (data from the YouPower app). In purple you can see how "Trentino prosumption request" (ToU signal) is by far the most engaging feature in CIVIS project (Italian launch of You Power was 11 March 2016)

[5] YouPower is the CIVIS ICT Platform, implemented in the test sites. More info about the functionality can be found in CIVIS Deliverable 3.3

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2.1 Energy evaluation: data collection and methodology

In order to test the CIVIS impact, a lot of data have been collected by local CIVIS partners investigating, describing and quantifying the behaviour of the involved families and communities in the consumption and production of energy and in the interaction with the ICT tools introduced by CIVIS project.

The data collection regards two time periods:

1) *Baseline data:* data concerning the period before the CIVIS intervention. These data are collected from local electrical DSO, CIVIS sensors and CIVIS Baseline Questionnaire;
2) *CIVIS data:* data concerning the period after the CIVIS intervention. These data are collected from local electrical DSO, CIVIS sensors and CIVIS Final Questionnaire.

The comparison between the two time periods is essential in order to identify and quantify the CIVIS impact.
The type of parameters considered in this Evaluation Report include:

- **Individual PV production and usage:** electricity production, electricity injected into grid, electricity self-consumption;
- **Electrical energy demand:** electricity demand from grid, total electricity demand;
- **Time of use (ToU) signals:** time distribution of high and low signals;
- **Thermal energy demand:** T outdoor, T indoor, space heating demand.

The analysis of all these parameters allows a complete overview of the energy behaviour of the involved families and communities considering both the electricity and heat demands.
The evaluation methodology described in the following chapter is subdivided in three parts:

1) Analysis of the ToU signal intervention for communities of energy prosumers;
2) Analysis of the electricity consumption & production;
3) Analysis of the heat demand.

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2.2 Analysis of the ToU signal intervention for communities of energy prosumers

2.2.1 ToU signals: introduction

As part of the European FP7 CIVIS project the introduction of a novel dynamic time-of-use (ToU) signal in an Alpine valley in the north of Italy was developed and tested. The aim of this ICT service is the management of the electricity demand side, generating a new form of flexibility for the local load balancing.

In CIVIS project, the involved participants were equipped with a predictive tool enabling an optimization of the demand profiles, improving the fit with the local renewable production. Several positive effects were expected, since it is a win-win situation for DSO, users, and Community. The positive impacts for the DSO are (1) increase the electricity produced from local own energy plants and consumed by members, (2) reduce the necessity of importing energy from the national grid. For the users the decrease of the energy tariff cost is the main impact. Finally, for the Community the (1) increase of the integration of the local renewable sources (in particular solar) with the local demand, (2) reduction of CO_2 emission footprint, (3) improvement of the local independency from the national grid, represent the most important achievements.

Key features of the dynamic time-of-use signal are the predictions of the local electricity demand and of the local renewable production (Hydro and PV). Prediction of local electricity demand is based on a statistical analysis of hourly historical data received from DSO (DSO members) while prediction of local electricity production is based on local weather forecast (solar radiation and rainfall) and hourly historical production data received from DSO.

Users energy behaviours are identified through detailed (3 hours' granularity) DSO metering before and after the introduction of the new ToU signal.

In Italy, the existing tariff scheme still does not reward virtuous behaviour of users such as

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prioritising self-consumption, lowering consumption during peak hours etc. So, not only there are no appropriate ICT tools capable of promoting this load balancing benefits but also, from the economic point of view, this is not encouraged.

In the CIVIS project it is currently proposed a simple signal, electrical consumption is encouraged in "green hours" ("low intervals") and discouraged in "red hours" ("high intervals"). A competition, promoted by local DSO and local CIVIS partners, supported the consumption in green hours financing social initiatives in the two communities. The idea is to study the social acceptability and quantify the potentialities and benefits for the electricity balance, as the basis for design a real incentive rate (ToU tariff), in collaboration with the DSO.

2.2.2 ToU signals: methods

The model calculates every day, for a time-horizon of 48 hours and for time intervals of 3 hours, a forecast of the electrical energy produced by DSO hydroelectric plants, by DSO photovoltaic plants and consumed by the DSO members of each consortium.

Therefore, the ToU signal reflects the total energy balance for each timeslot. If the energy balance is positive (consortium overproduction), the time-interval is labelled as "low", otherwise (consortium underproduction) it is labelled as "high". If during one day there is less than 3 "low intervals" this minimum value is reached considering as "low" the less over productive timeslot.

Concerning the hydroelectric production, each consortium regularly estimates the quantity of hydroelectric energy that will be produced. CEIS produces this forecast every 2 weeks while CEDIS only once a year. In "CIVIS ToU signal" are directly used these data (send by DSO to the CIVIS server). CEIS data are, of course, more reliable than CEDIS data.

Electricity consumption by DSO members can be predicted, with good accuracy, using historical data to identify an aggregated average profile for each of the two consortium. Moreover, for each month and for each weekday, an average profile has been identified using historical data referring to the year 2013.

A **detailed predictive model for the DSO PV production has been designed**, based on the solar radiation forecasts produced by the meteorological model provided by the National

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Oceanic and Atmospheric Administration (http://www.noaa.gov/ , http://nomads.ncep.noaa.gov/), which is openly accessible. From the radiation we obtain the amount of energy produced, using a linear model previously fitted to local historical data of solar radiation (data from Meteotrentino, http://www.meteotrentino.it/) and local PV production (data from DSO plants). The linear model has been identified using data that cover the whole 2013.

The model queries the NOAA's server and as soon as data for the next day are available, it produces the forecast. The data are downloaded every day at 4 AM.

Despite ToU signals have started to be processed from 13/01/2016, their viewing by CIVIS users have been possible, in YouPower, only from 11/03/2016.

2.2.3 DSO electrical balances

2.2.3.1 CEIS

CEIS produces electricity using only renewable sources, it has the ownership of 1 hydropower plant (4 MW) and 5 PV plants (1 MW) connected to its own electric grid (Table 2).

Table 2 Number of plants (with installed power) property of CEIS and connected to its own electric grid (2013)

Renewable energy source	Number of plants	Installed Power (kW)
PV	5	1,045
Hydropower	1	4,000
Total	***5***	***5,045***

The local electricity distribution grid of medium voltage (MV) and low voltage (LV) is owned by CEIS. Two MV interconnection points with the national grid ensure the continuous, bidirectional, exchange of electricity between CEIS local grid and national grid. CEIS sells excess production to and buy lacking electricity from the regional company called Trenta S.p.A. While the electrical production of CEIS is 100 % from renewable sources, electricity purchased from the national grid present a fraction of 29.5% (year 2013). CEIS estimates for

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the year 2013 a cost for the local electrical generation on average equal to 56 €/MWh, buy electricity from Trenta S.p.A costs on average 66 €/MWh.

As CIVIS project stakeholder, CEIS has provided hourly data of injection into the grid of its own plants as well as hourly data of consumption from grid of its own members (year 2013, Figure 4).

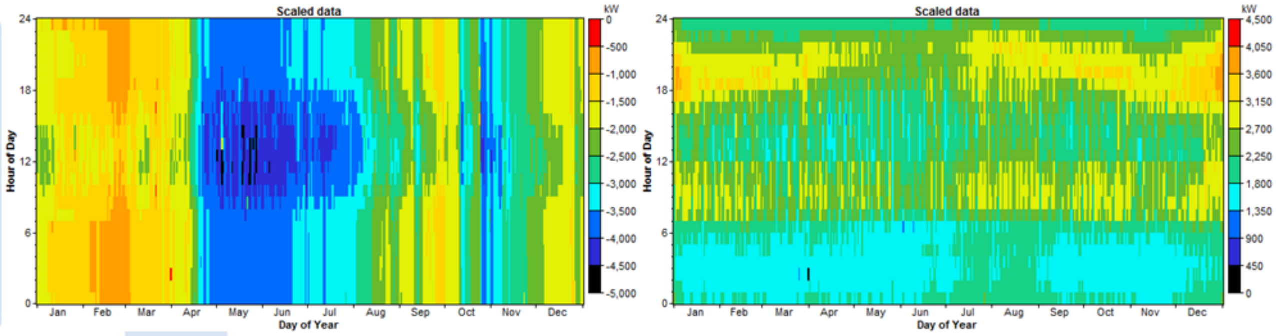

Figure 4 Comparison between hourly injection of CEIS plants (sx) and hourly consumption of CEIS members (dx).

While electricity consumption shows small variations at monthly level, electricity injection shows considerable fluctuations. Production from hydro largely dominates the overall production in CEIS and is dependent on direct rainfall and snowmelt (reaching a pick in spring and in autumn). Moving to PV, its production is dependent on the solar radiation, with the highest values in summer.

The analysis of grid balances needs at least an hourly detail. Injection profiles are not able to obtain a suitable fitting with consumption profiles, the latter characterized by a morning peak and an evening peak. Hydro injection is almost not regulated due to the absence of a real storage basin. Regulation activity couldn’t be performed also for PV (no storage).

In Figure 5 the electricity exchanges with the national grid (import and export with Trenta S.p.A.) are quantified and analysed. During the reference year 2013 CEIS imported 3.4 GWh (peak of import 2.4 MW) and exported 5.2 GWh (peak of export 3.1 MW).

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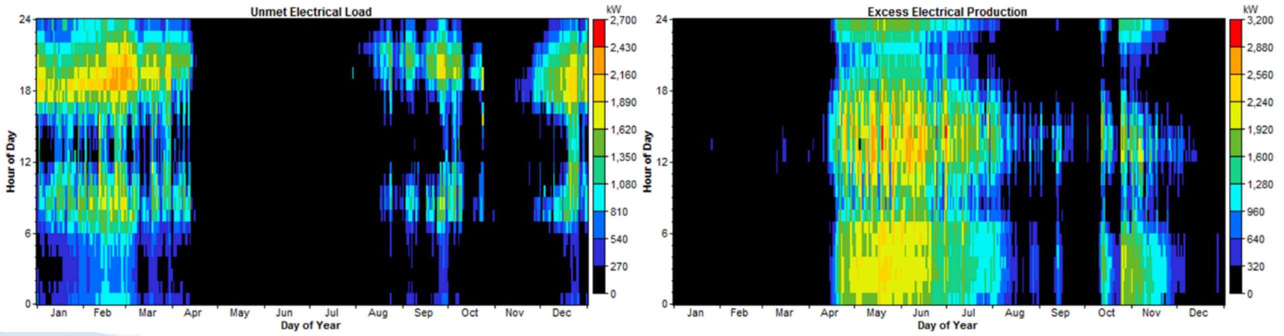

Figure 5 CEIS el. grid: power purchased from National Grid (hourly, 2013, sx) and power sold to National Grid (hourly, 2013, dx)

These data describe an energy system characterized by a high fraction of renewable energy production. This energy is unpredictable and not programmable, there is a clear problem of energy balancing. Indeed, could interleave periods of high production with excess energy and periods of low or no production with deficit energy. These high intermittent power flows put stress and imbalances in the electric grid of distribution and transmission, making difficult to ensure a continuous supply with high quality for the connected users.

In order to improve the match between production and demand, several storage interventions are possible: (1) improve the managing of the existing small hydro storage reservoir or enlarging it, (2) introduce pumping hydro, (3) introduce other forms of storage like batteries or hydrogen.

There is also another, far cheaper, possible intervention: work on the demand side and promote the load shifting. This is the goal of the ToU signal proposed in CIVIS project.

2.2.3.3 CEDIS

CEDIS produces electricity using only renewable sources, it has the ownership of 3 Hydropower plant (4.7 MW) and 2 PV plants (0.8 MW) connected to its own electric grid (Table 3).

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Table 3 Number of plants (with installed power) property of CEDIS and connected to its own electric grid (2013)

Renewable energy source	Number of plants	Installed Power (kW)
PV	2	826
Hydropower	3	4,679
Total	***5***	***5,505***

The local electric distribution grid of medium voltage (MV) and low voltage (LV) is owned by CEDIS. One MV interconnection point with the national grid ensure the continuous, bidirectional, exchange of electricity between CEDIS local grid and national grid. CEDIS sells excess production and buy lacking electricity with the regional company called Trenta S.p.A. While the electrical production of CEDIS is 100% from renewable sources, electricity purchased from the national grid present a fraction of 29.5% (year 2013). CEDIS estimated for the year 2013 a cost for the local electrical generation on average equal to 30 €/MWh, buy electricity from Trenta S.p.A costs on average 66 €/MWh.

As CIVIS project stakeholder, CEDIS has provided hourly data of injection into the grid of its own plants as well as hourly data of consumption from grid of its own members (year 2013, Figure 6).

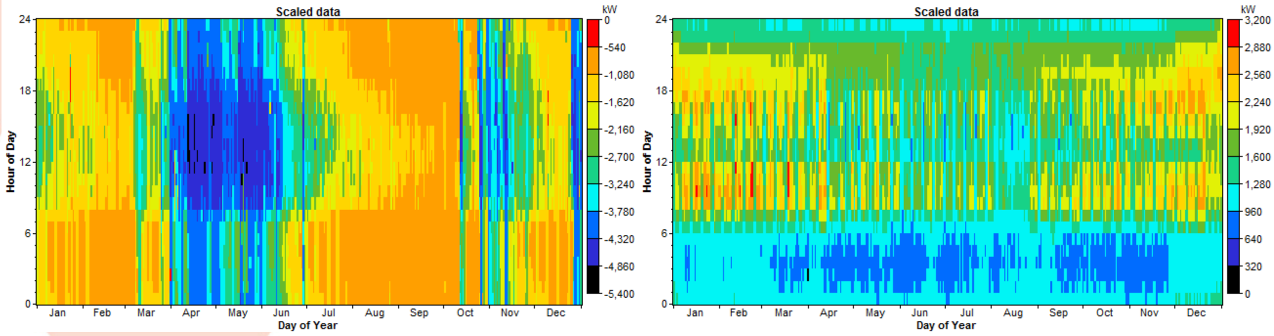

Figure 6 Comparison between hourly injection of CEDIS plants (sx) and hourly consumption of CEDIS members (dx).

The consumption and production outlooks are very similar to those of CEIS (similar customers and similar production technologies). While electricity consumption shows small

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variations at monthly level, electricity injection shows considerable fluctuations. Production from hydro largely dominates the overall production in CEDIS and is dependent on direct rainfall and snowmelt (usually reaching a pick in spring and in autumn). Moving to PV, its production is dependent on the solar radiation, with the highest values in summer.

The analysis of grid balances needs at least an hourly detail. Injection profiles are not able to obtain a suitable fitting with consumption profiles, the latter characterized by a morning peak and an evening peak. Hydro injection is almost not regulated due to the absence of a real storage basin. Regulation activity couldn't be performed also for PV.

In Figure 7 the electricty exchanges with the national grid (import and export with Trenta S.p.A.) are quantified and analyzed. During the reference year 2013 CEDIS imported 2.2 GWh (peak of import 2.2 MW) and exported 7.4 GWh (peak of export 4.0 MW).

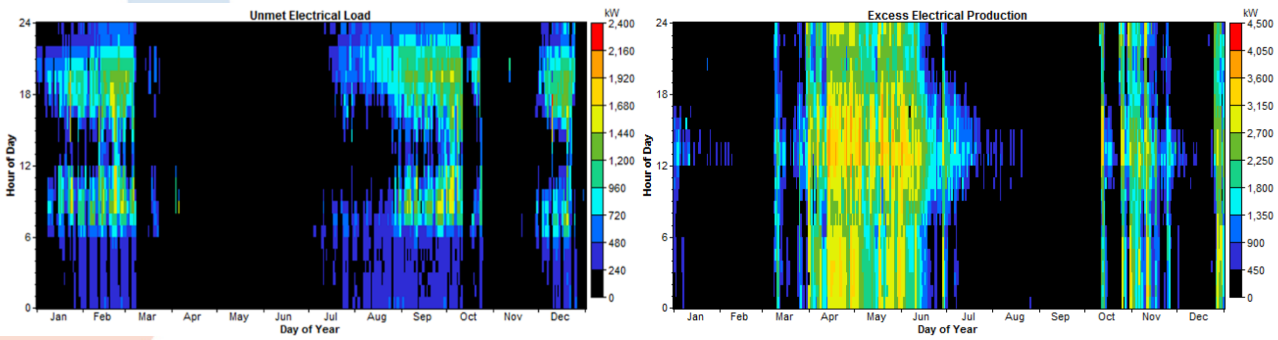

Figure 7 CEDIS el. grid: power purchased from National Grid (hourly, 2013, sx) and power sold to National Grid (hourly, 2013, dx)

Same considerations of CEIS can be done also for CEDIS's energy system characterization (high fraction of renewable energy production, production unpredictable and not programmable, clear problem of energy balancing)

This is why also in CEDIS the ToU signal represents an interesting solution, working on the demand side and promoting the load shifting. This is the goal of the ToU signal proposed in CIVIS project.

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2.2.4 ToU signals: time distribution of low signals

As described before, if the electrical energy balance is positive (consortium overproduction), the corresponding time-interval is labelled as "low", otherwise (consortium underproduction) it is labelled as "high". If. in one day there are less than 3 "low intervals" the minimum value is reached, considering as low the less over productive timeslot.

Therefore, both in CEIS that in CEDIS, time distribution of "low signals" reflects the excess production.

In CEIS (Figure 8), "low signals" intervals are a few during the winter period (from January to March), mainly allocated during the night 00:00 – 06:00 and during the midday (12:00 – 15:00). In April the "low signals" reach a maximum availability (about 50%), in this month it is verified an abundant overproduction from Hydro (mainly) and PV (secondly) resources. The most favourable periods are during the night 00:00 – 06:00 and during the midday/afternoon (12:00 – 18:00). In the following two months (May and June) the "low signal" availability remains frequent and allocated mainly during the midday/afternoon (12:00 – 18:00) and the night 03:00 – 06:00. In May and June gradually increases the influence of PV production in the CEIS energy balances.

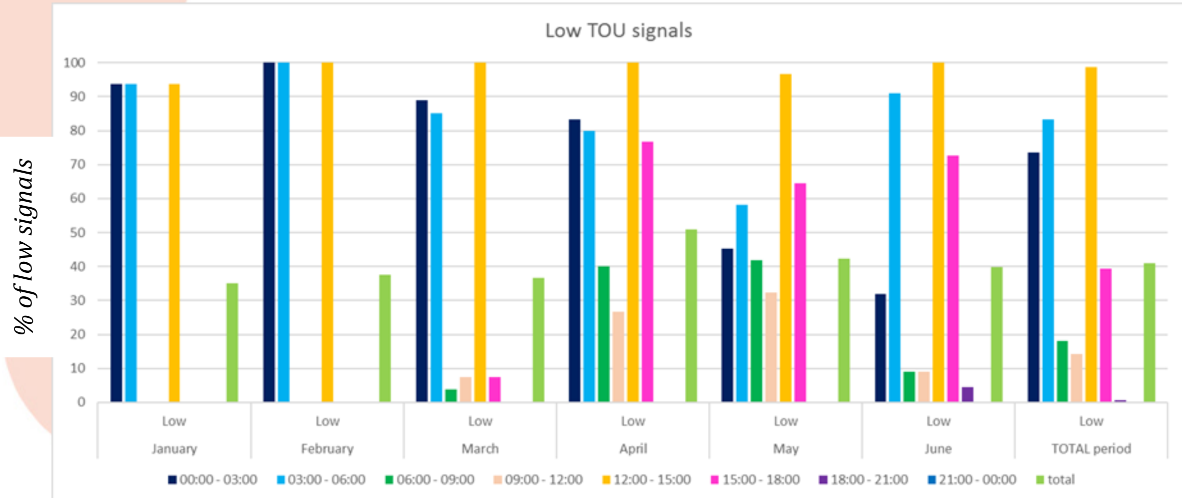

Figure 8 CEIS: time distribution of low signals (2016, % of low signals in the considered time slot)

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Moving to CEDIS (Figure 9), "low signals" intervals are a few during the winter period (from January to February), mainly allocated during the night 00:00 – 06:00 and during the midday (12:00 – 15:00). In March the "low signals" availability increases (over 40%), in this month it is reached an abundant overproduction from Hydro (mainly) and PV (secondly) resources. The most favourable periods are during the night 00:00 – 06:00 and during the midday/afternoon (12:00 – 18:00). In the following three months (from April to June) the "low signal" availability remains frequent, reaching the peak in June. In April the most favourable allocations are during the midday/afternoon (12:00 – 18:00) and the night 00:00 – 06:00; in May and June during the midday (9:00 – 18:00). In the last two considered months (May and June) gradually increases the influence of PV production in the CEDIS energy balances (overproduction concentrated during the midday).

Both in CEIS and in CEDIS, considering the demand profiles of their members and the time distribution of the "low signals", a demand shifting is required moving the use of electrical appliances from morning and evening to night and midday.

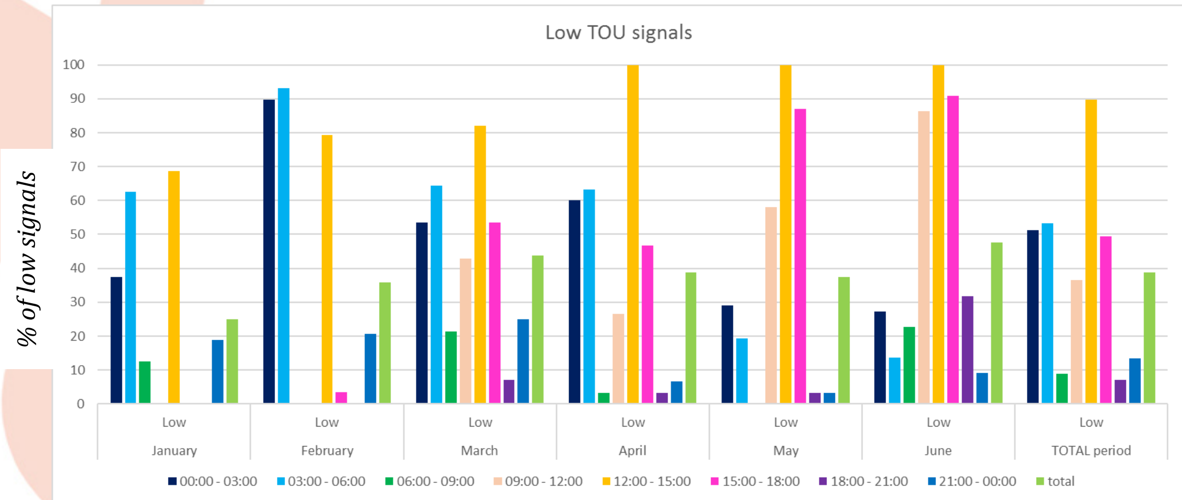

Figure 9 CEDIS: time distribution of low signals (2016, % of low signals in the considered time slot)

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2.2.5 Analysis of the withdrawal profiles

The analysis of the withdrawal profiles (electricity consumption from the grid) in the two CIVIS Italian communities (CEIS and CEDIS) is divided in an analysis of the % of withdrawal shifting and in an analysis of the % of withdrawal in "low signal".

However, at the time of writing this report, the lack of individual historical withdrawal profiles prevents the comparison of each user with himself, in a "before" and "during" CIVIS project for the same period of the year.

2.2.5.1 CEIS

In Figure 10 it is represented the average withdrawal profile of CEIS participants in CIVIS project. This profile has a monthly variability due to seasonal lighting effects. As a whole maintains a characteristic primary peak in the evening (around 18:00 – 20:00) and a secondary peak in the morning (around 7:00 – 9:00).

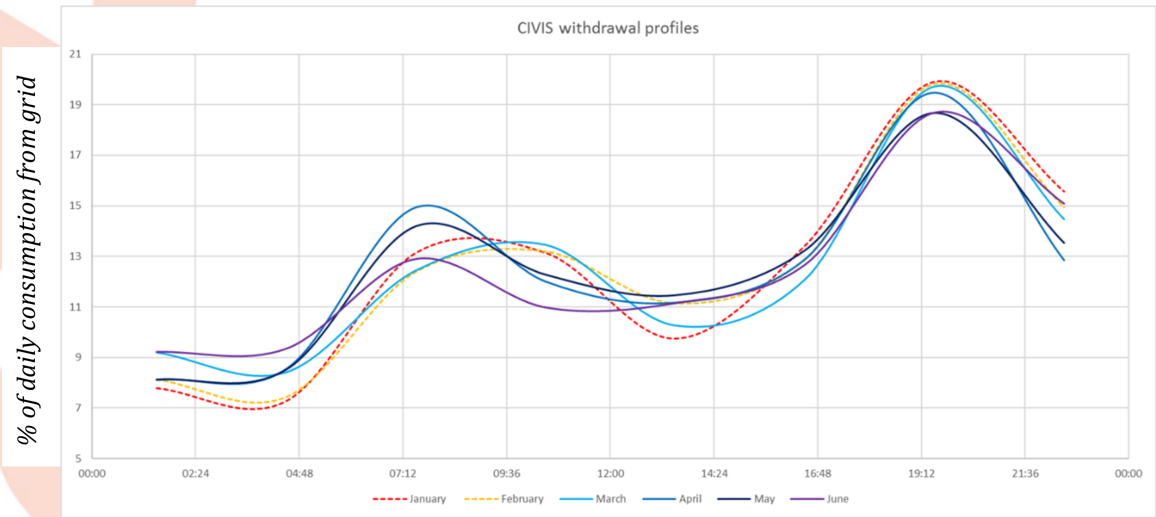

Figure 10 Average withdrawal profile of CEIS participants in CIVIS project (2016, % of the daily consumption from grid)

A detailed analysis has considered the percentage of withdrawal shifting and the percentage of withdrawal in "low signal", both on an individual and on a consortium scale. Indeed, it is not

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sufficient to shift the consumption but this shifting should be directed to "low intervals".

Starting with the percentage of withdrawal shifting this is calculated comparing the pre-YouPower period (13/01/2016 – 10/03/2016) and the YouPower period (12/03/2016 – 24/06/2016). For the pre-YouPower period it is calculated the average daily energy profile, in kWh and with 3-hour time intervals. In the YouPower period each time slot (3 h) is compared with the equivalent time slot in the average daily energy profile of the pre-YouPower period. For each month the % of withdrawal shifting (w.s.) is calculated as:

$$\%\ of\ w.s. = \frac{100}{monthly\ grid\ el\ cons} * \sum (grid\ el\ cons\ time\ slot\ YP - grid\ el\ cons\ time\ slot\ pre\ YP)$$

Individual results are shown in Figure 11. CIVIS participants are divided in users without PV and users with PV, in green users registered in YouPower. During the YouPower period, at consortium scale (Table 4), YouPower users do not show significant higher shifting compared to the other users.

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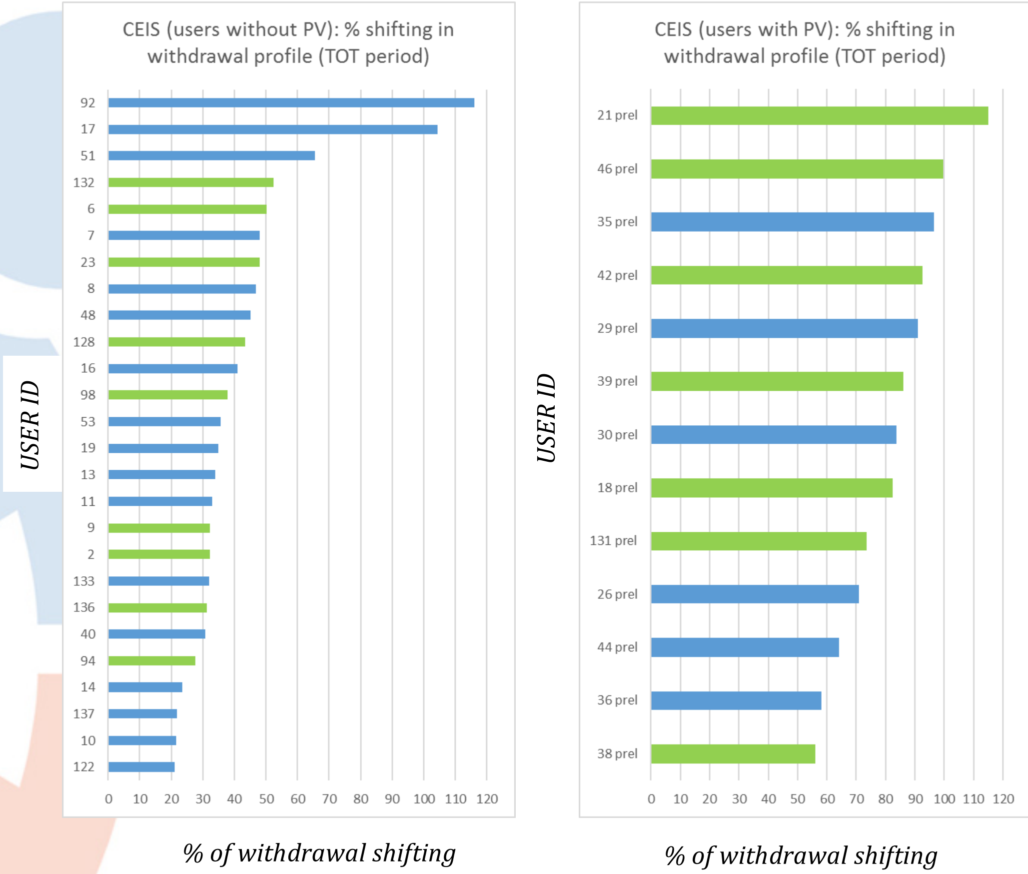

Figure 11 Individual percentage of withdrawal shifting, in green YouPower users for the total (TOT)trial period (You power users in green, non users in blue)

Table 4 CEIS percentage of withdrawal shifting

	without PV		with PV	
	YP	no YP	YP	no YP
March	34.6	40.6	81.1	73.0
April	40.6	45.9	91.6	68.5
May	37.4	47.8	104.7	92.5
June	44.6	44.2	80.6	93.6
TOT	**39.5**	**44.4**	**86.5**	**77.4**

Moving to the **percentage of withdrawal in "low signal"** (percentage of w. in ls), this is

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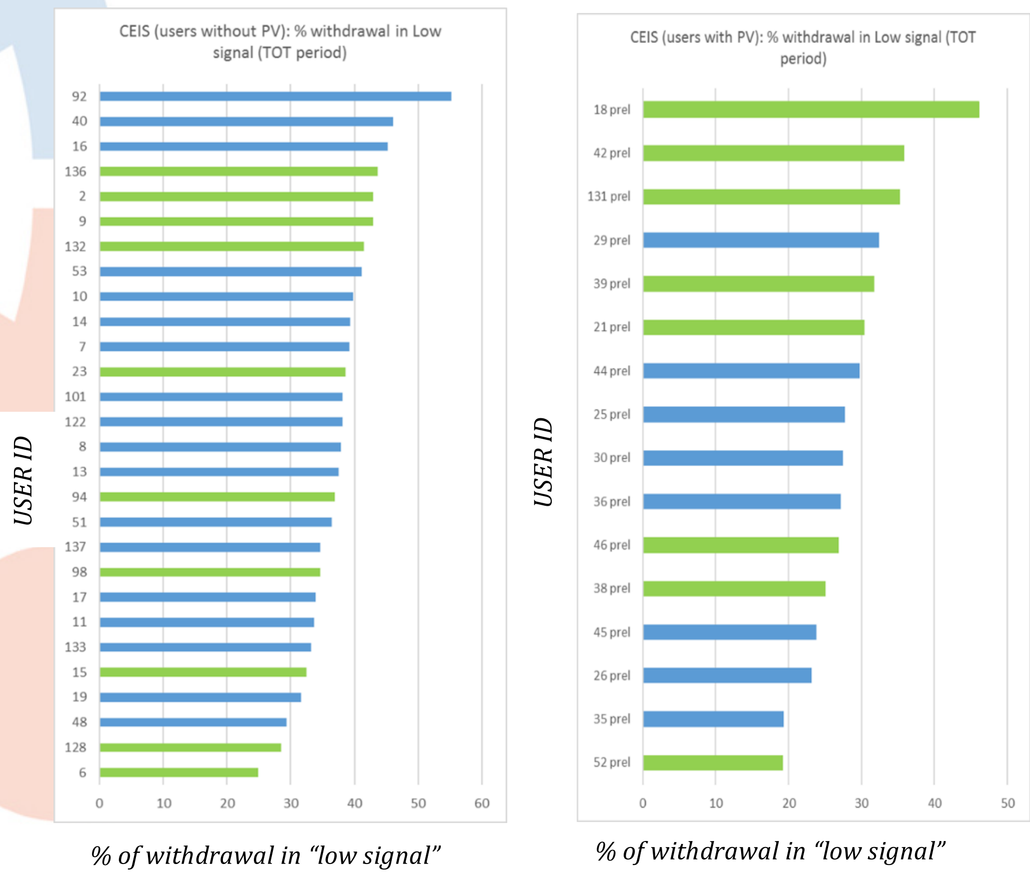
calculated for each month, in the YouPower period (12/03/2016 – 24/06/2016), as:

$$\% \, of \, w. in \, ls \; = \frac{100}{monthly \, grid \, el \, cons} * grid \, el \, cons \, in \, ls$$

Individual results are shown in Figure 12 CIVIS participants are divided in users without PV and users with PV, in green users registered in YouPower. **<u>During the YouPower period, at consortium scale (Table 5), YouPower users show similar performance (- 1.7%) compared to the other users in the "without PV" category, slightly better (+ 5 %) in the "with PV" category.</u>**



<u>Figure 12 Individual percentage of withdrawal in "low signal", in green YouPower users for the total (TOT) trail period (You power users in green, non-users in blue)</u>

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Table 5 CEIS percentage of withdrawal in "low signal"

	without PV		with PV	
	YP	no YP	YP	no YP
March	29.2	27.3	26.6	22.3
April	43.4	45.2	36.7	32.8
May	37.1	40.4	37.9	24.0
June	35.0	35.5	28.3	30.2
TOT	**36.7**	**38.4**	**31.3**	**26.3**

In summary with CEIS YouPower users do not show significant higher shifting compared to the other users. YouPower users show similar performance (- 1.7%) compared to the other users in the "without PV" category, slightly better (+ 5 %) in the "with PV" category.

2.2.5.1 CEDIS

In Figure 13 it is represented the average withdrawal profile of CEDIS participants in CIVIS project. This profile has a monthly variability due to seasonal lighting effects. As a whole maintains an evident peak in the evening (around 18:00 – 20:00) and a minimum consumption in the night zone (22:00 – 5:00). Compared to CEIS it is not evident a secondary peak in the morning, this reflect the different types of involved CIVIS users, probably due to differences in the work life.

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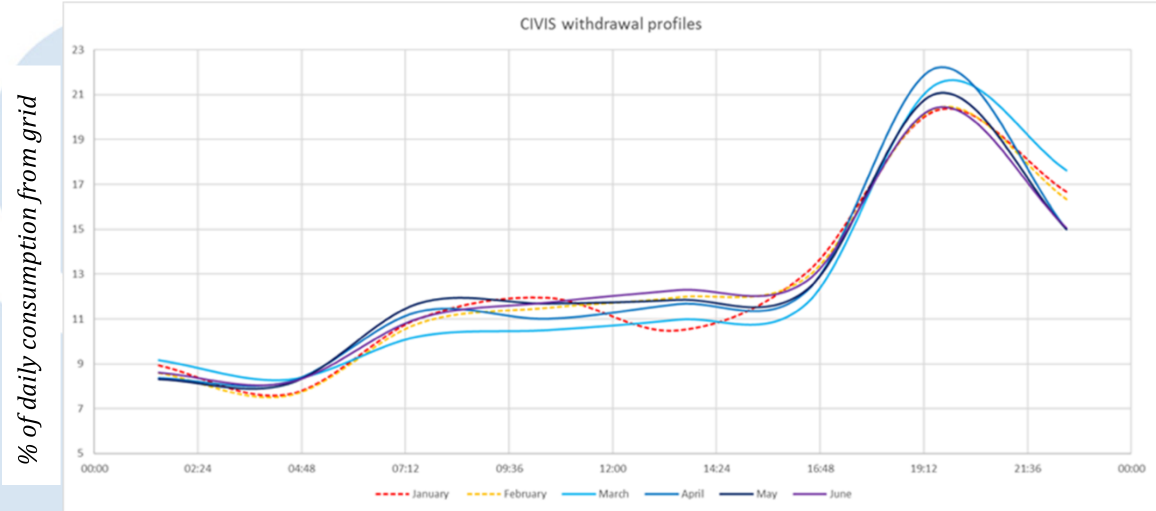

Figure 13 Average withdrawal profile of CEDIS participants in CIVIS project (2016, % of the daily consumption from grid)

As for CEIS also for CEDIS a detailed analysis has considered the percentage of withdrawal shifting and the percentage of withdrawal in "low signal", both on an individual and on a consortium scale. Indeed, it is not sufficient to shift the consumption but this shifting should be directed to "low intervals".

Starting with the **percentage of withdrawal shifting**, individual results are shown inFigure 14 CIVIS participants are divided in users without PV and users with PV, in green users registered in YouPower. **During the YouPower period, at consortium scale (Table 6), YouPower users do not show significant higher shifting compared to the other users.**

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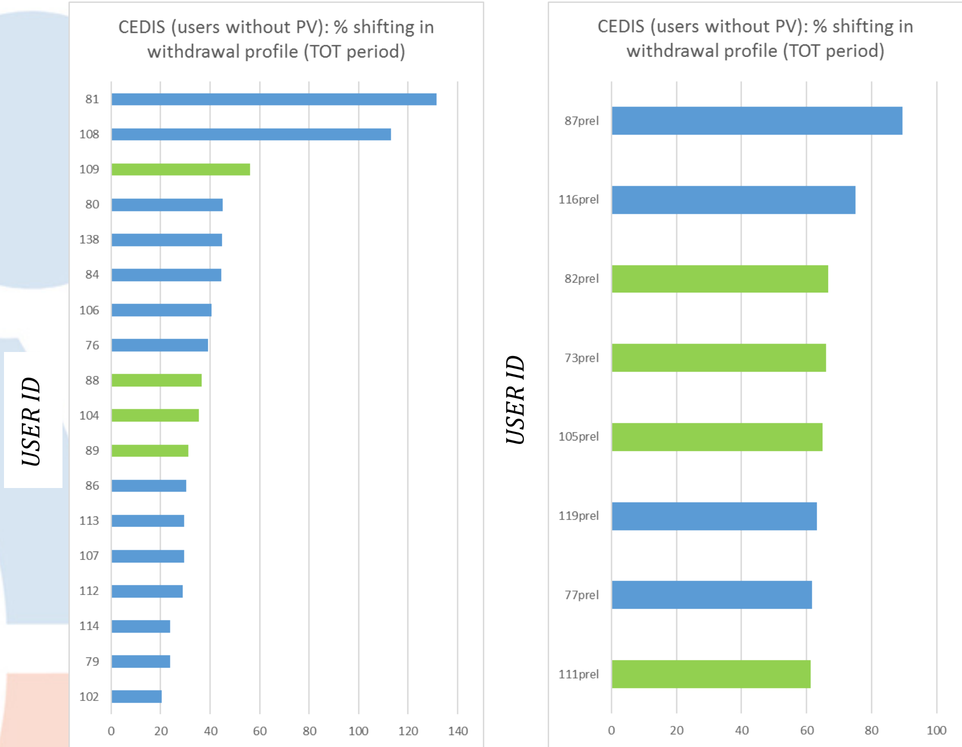

Figure 14 Individual percentage of withdrawal shifting for total (TOT) trial period, in green YouPower users, non users in blue.

Table 6 CEDIS percentage of withdrawal shifting

	without PV		with PV	
	YP	no YP	YP	no YP
March	41.3	39.8	56.6	70.3
April	39.0	49.5	62.4	75.0
May	59.6	52.5	64.0	61.8
June	45.8	46.2	75.7	80.3
TOT	**39.9**	**46.1**	**64.7**	**72.4**

Moving to the percentage of withdrawal in "low signal", individual results are shown inFigure

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15. CIVIS participants are divided in users without PV and users with PV, in green users registered in YouPower. **During the YouPower period, at consortium scale (Table 7), YouPower users show the same performance compared to the other users in the "without PV" category, slightly worse (- 8 %) in the "with PV" category.**

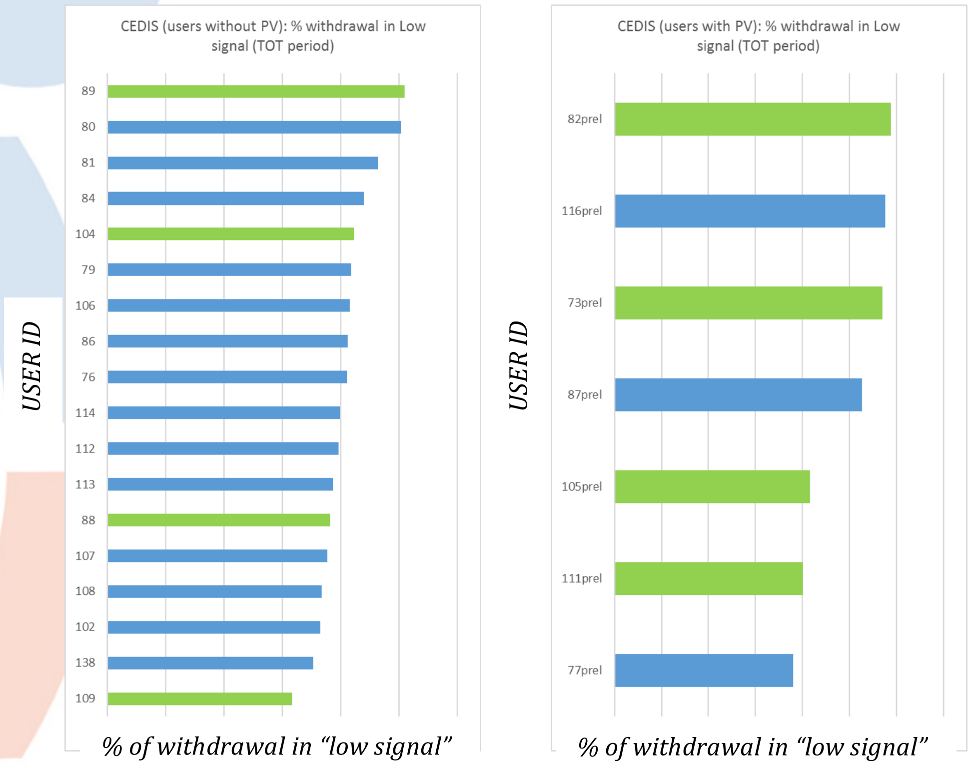

Figure 15 Individual percentage of withdrawal in "low signal", for the total (TOT) trial period (You power users in green, non-users in blue)

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Table 7 CEDIS percentage of withdrawal in "low signal

	without PV		with PV	
	YP	no YP	YP	no YP
March	40.6	41.7	28.0	34.4
April	32.1	34.8	25.9	26.2
May	35.2	36.9	18.3	12.8
June	47.9	48.5	28.8	21.5
TOT	**40.8**	**40.8**	**24.7**	**32.7**

In summary for CEDIS YouPower users do not show significant higher shifting compared to the other users. YouPower users show the same performance compared to the other users in the "without PV" category, slightly worse (- 8 %) in the "with PV" category

2.2.6 Social acceptance of interventions and participants' behaviours

The YouPower platform (described in CIVIS D.3.3) has been deployed, while also a parallel process in support to households' engagement started: the participatory energy budget process. The description of the participatory energy budgeting process can be found in CIVIS D5.3, with a detailed analysis of the results.

In this paragraph, we will discuss user's attitudes and social acceptance connected to the interventions carried out by CIVIS. We combine the data coming from the baseline questionnaire and the two questionnaires administered one in May and the final one in July, and the evaluation coming from two focus groups held in July 2016 in CEIS and CEdiS area.

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2.2.6.1 External motivations

From the very beginning participants expressed concerns and attention to younger generations and the environment. In the baseline questionnaire (see CIVIS D 7.2) participants divided mostly in two between the one that want to do something more for the environment and the one satisfied with their environmental behaviours. This attitude came out also during the focus groups, where from one side participants described the investments and their attitude toward environment. Quoting a participant: *"I used PV panels for 20 year now, I was one of the first [...] We are convinced about that, other people need to understand it [...] Before I was uneducated about those topics, but now I am more aware because I am more aware of the planet, of my territory..."*.

This kind of attitude toward the environment and the energy is common with other participants of the project, and the pro-environmental motivation is the main one for using the YouPower app for respondents of the first questionnaire (for a detailed analysis see CIVIS D 5.3).

2.2.6.2 ToU signals: social acceptance

Whether from the technical point of view the ToU signal intervention is interesting, its potential benefits can be achieved only if it is manifested a social acceptability.

The analysis of the ToU signal social acceptance is based on the data collected in the CIVIS Final Questionnaire, performed in the Italian Pilot Sites during July 2016.

The CIVIS Final Questionnaire has been completed by 55 families, 37 in CEIS area and 18 in CEDIS area. Of these, are registered in YouPower 18 CEIS families (49 %) and 7 CEDIS families (39 %).

For the YouPower users, a first investigation considers the usefulness of the ToU signals. In a scale from 1 (strongly disagree) to 5 (totally agree), Italian families on average partially agree that the ToU signal is useful for planning activities involving the energy use (CEIS 3.2, CEDIS 3.6) and for reducing electrical consumption (CEIS 3.0, CEDIS 3.1).
However, difficulties to follow ToU signals are not negligible (Figure 16) the stronger are work life, family life and fixed habits. From this point of view, the low family engagement expressed by respondents it is an added difficulty to shift consumption without changing daily

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routines or without the help of domotics, automation or storage. The lack of technologies and the difficulties to have a cooperation with other family members has been pointed out by participants as difficulties: *"at an individual level would be a solution, instead of… at the family level we already have enough problems, a more technological management. For example some smart storage[…]".*

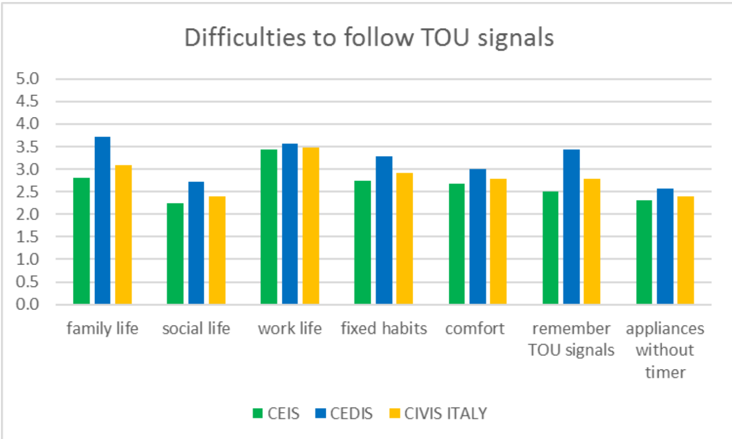

Figure 16 Difficulties to follow ToU signals, in a scale from 1 (not difficult at all) to 5 (very difficult)

A significant number of families declare to have shifted their electrical consumptions following ToU signals, in CEIS 63 % among YouPower users, in CEDIS 71 %.

Shifted consumptions include washing machine, dishwasher, dryer and vacuum cleaner. These electrical appliances are consistent with the activities with higher shifting potential identified in CIVIS d 2.1b (washing, drying, dishwasher and water heating, representing about 22 % of the total electricity consumed in the domestic sector). The usage of other appliances is perceived as non-shiftable, *"it's only the washing machine that can be [shift]… the fridge, the lights [not]… like the 90% of consumption"* a user said during a focus group.

The presence of PV panels is a variable that create new motivation for shifting or for changing consumption behaviours and for increase cooperation within family members: participants with PV panels already pay attention about when use energy, quoting a user from a focus group: *"[…]*

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sometimes with my wife we talk about it, and we try to exchange some opinion, mostly when there is the thing of the energy we produce, how to use it and not use together dishwasher and washing machine to not withdraw energy from the grid".

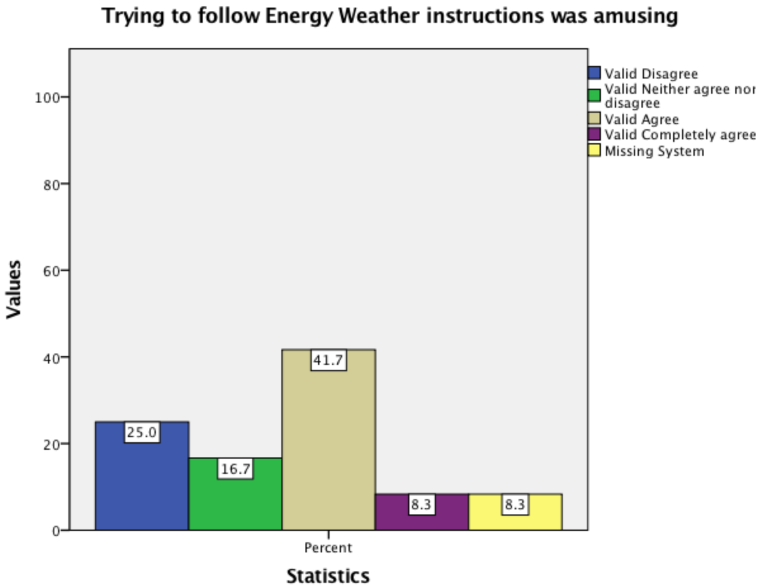

Figure 17 Distribution (%) of perception of amusement following ToU signal

As shown in Figure 17, around 50% of respondents felt amusement trying to follow the ToU signal, but during July focus group during the discussion about the ToU and the platform participant expressed the willingness to have some kind of push notification instead of having to control the app continuously. They felt that their daily lives routine could be put under discussion, while with a push notification to be set when they are at home could be easy to adapt.

2.2.6.3 Energy Tips and Historical Data

The main feature of YouPower for the Trentino test sites is Energy Weather, but the application has also other two features: Energy Tips, which is common with the Swedish part and the data visualization part.

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Asked about the Energy Tips section of the platform respondents to the May questionnaire expressed a general consensus among the usefulness of this feature, while when asked about how the select the actions to take they answered that they select them for their impact (Figure 18). This is also what emerged from the focus groups, where participants expressed a general interest for the tips and curiosity about environmental and energy savings behaviour unknown for them. Quoting two participants from the two focus groups: *"one thing that I did not do and that I will hand to do, it's to defrost things in the fridge", "there are some small tips like to not wash dishes with running water […]small things but if one did not know about it."*

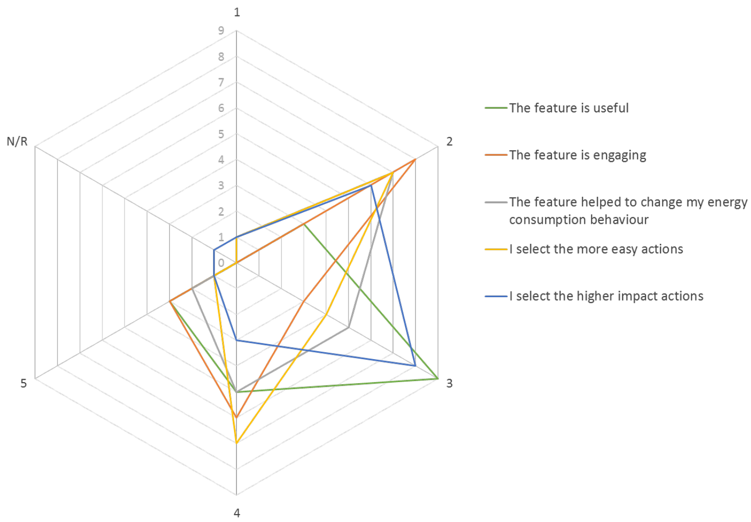

Figure 18 Opinions about Energy Tips feature

A general usefulness and a help to increase energy awareness came also from the data visualization feature, where users can check their consumption and/or production real-time or look at historical data Figure 19. Users tried to monitor their consumption in order to understand if savings are possible and how: *"for me has been a positive things, if one notice what he consumes, he can make some calculations, like today I consumed that and last week I consumed less because maybe I did some calculations to see if I could save".*

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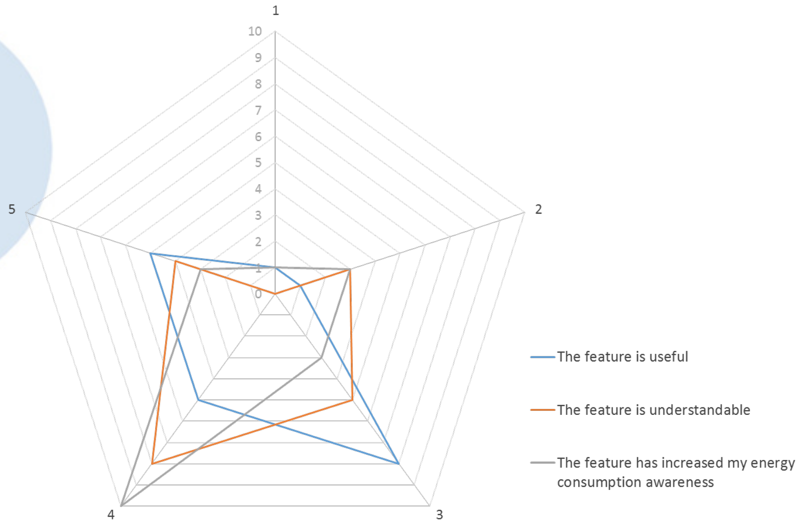

Figure 19 Opinions about data display feature

2.2.6.4 Gender and Energy

The need of flexibility in order to follow the ToU signal motivated one third of the respondents' family members to take care of chores usually carried out by someone else (see Figure 20). Dishwasher and washing machine are the two appliances that are used in different time and or by different people. We asked directly in the questionnaire which kind of changes happened: a user for instance said that the husband took care of the washing machine instead of the wife. But during the focus groups a gender gap emerged, in several occasions in the discussion came out that women in the households are in charge of the chores, while at the opposite males are the one more interested in using the platform and "play" with the technology.

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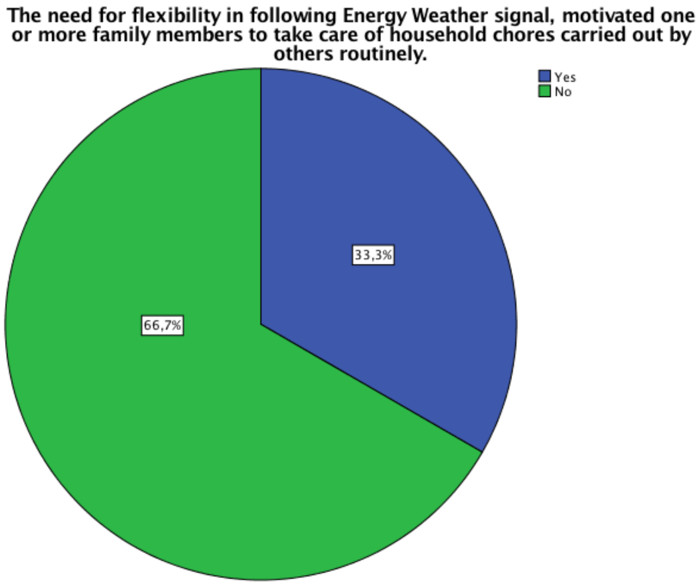

Figure 20 Family participation to consumption shifting

Male participants explicitly stated how roles in family are clearly defined, with the wife as a *"manager of the house"* which takes care of charging and programming the start of appliances, quoting a participant: *"if I need to repair the washing machine I can do it, but starting it's hard for me"*. Participants to the focus groups discussed how they tried to make their wives more interested or how they tried to teach how to use YouPower, but with few results in establishing new practices within the family.

2.2.6.5 Analysis of the electricity consumption & production

Concerning the electricity consumption, a first analysis regards to the changes in the electrical appliances equipment during CIVIS project. Data from CIVIS Final Questionnaire indicate that both in CEIS and in CEDIS about 17% of CIVIS families have replaced or installed new electrical appliances, among them many new installations concern induction hobs and dryers. (see Figure 21).

To the question: "Have you taken measures to reduce electricity consumption?" CIVIS

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participants for the most part, about 60 %, declare "yes as before", a good percentage, about 20%, "more than before" and only about 20 % "no". **CIVIS participants have therefore in general a positive attitude for energy saving (electricity) and CIVIS project contributed for about 20 % of them to improve this good energy behaviour.**

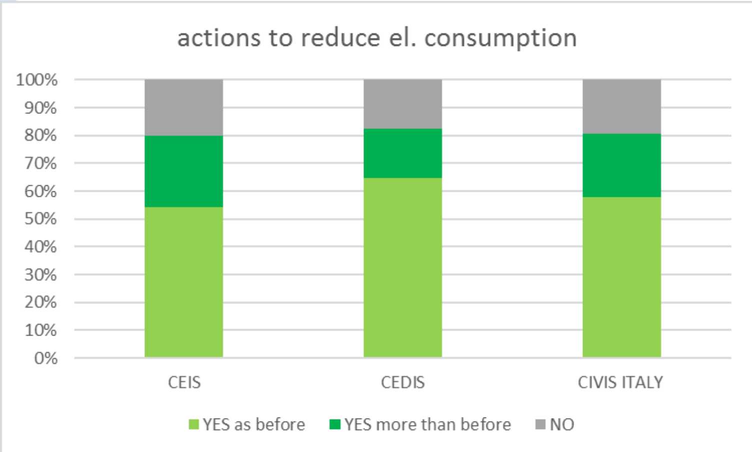

Figure 21 Results of the question "Have you taken measures to reduce electricity consumption?"

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2.3 Results of electrical data analysis in Italian test site

In the following section are discussed the results of the **electricity data analysis** in the two Italian communities (CEIS and CEDIS) with **individual and consortium comparisons between CIVIS period (01/07/2015 – 30/06/2016) and pre-CIVIS period (considering three years and their trend)**. The electrical data analysis regards PV production, PV injection into grid, PV self-consumption (%), electrical consumption from grid, total electrical consumption (from grid and from PV self-consumption). **Data are provided by the two Italian DSO (CEIS and CEDIS).**

2.3.1 CEIS

PV production is generally higher when compared to 2014 (21/21 users, CEIS +6.8 %) as shown in Figure 22. This increasing can be attributed to more favourable conditions in solar radiation.

For the same motivation also PV injection in CEIS grid is generally higher when compared to 2014 (18/21 users, CEIS +7.4 %) as shown in Figure 23.

PV self-consumption (% of self-consumption of the PV self-produced) is increased for 11/21 of CEIS users comparing to 2014 as shown in Figure 24**.** The percentage of PV self-consumption in CEIS is stable at around 28 %.

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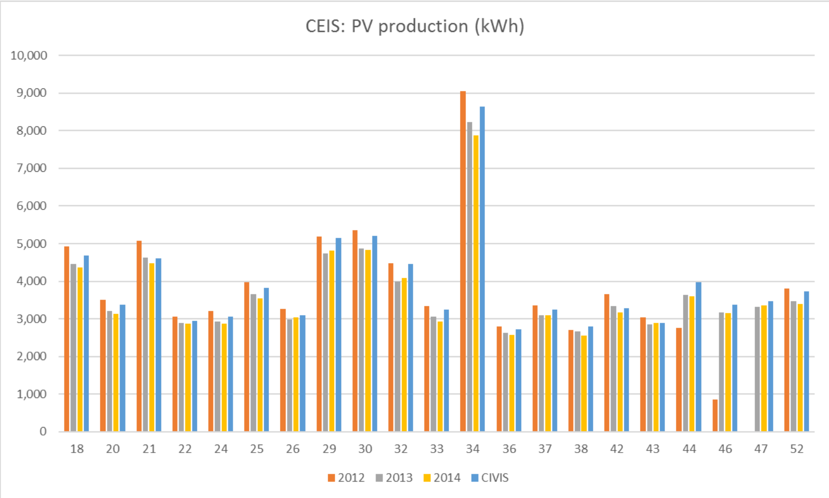
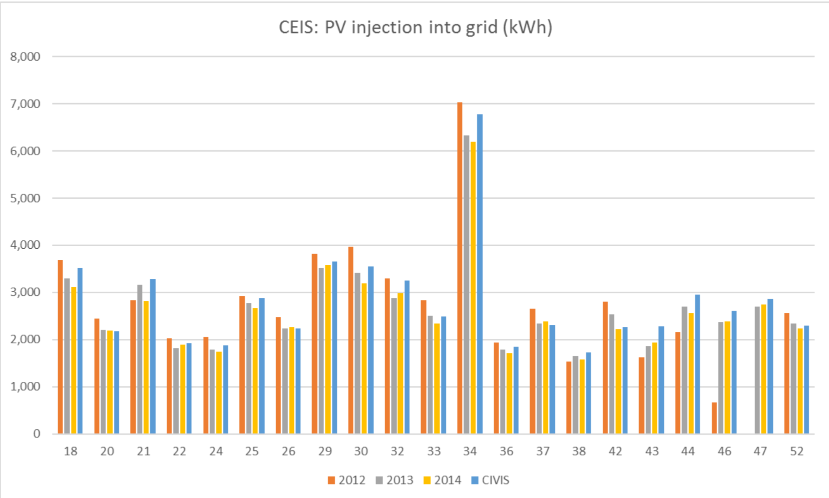


	2012	2013	2014	CIVIS
kWh	77,382	77,844	76,569	81,765
var %		0.6	-1.6	6.8

Figure 22 PV production of CEIS participants in CIVIS project



	2012	2013	2014	CIVIS
kWh	55,338	56,215	54,715	58,773
var %		1.6	-2.7	7.4

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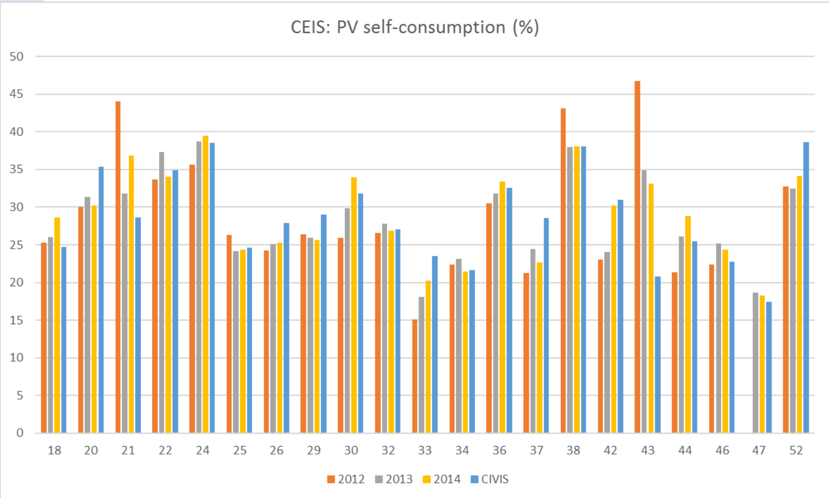
Figure 23 PV injection into grid of CEIS participants in CIVIS project



	2012	2013	2014	CIVIS
%	28.5	27.8	28.5	28.1

Figure 24 PV self-consumption (%) of CEIS participants in CIVIS project

In CIVIS, considering the trend 2012-2014, **electricity consumption from grid is below the trend for half of CEIS users (21/42)**, for the other half is above. In aggregate terms, for the CEIS consortium, the trend during the three years 2012-2014 suggests for the CIVIS period (01/07/2015 – 30/06/2016) an expected increase of +5.5 % (compared to 2014) as shown in Figure 25. The recorded data indicate a higher increasing, +16.1 %. The general high increase in electricity consumption from grid is mostly due to the installation of new electrical appliances (dishwasher, dryer, electric hob, electric heater, ICT), supposed to be particularly accelerated in the period 2014 – 2015/2016.

In CIVIS, considering the trend 2012-2014, **total electricity consumption (from grid and from PV self-consumption) is below the trend for half of CEIS users (21/42)**, for the other half is above. In aggregate terms, for the CEIS consortium, the trend during the three years 2012-2014 suggests for the CIVIS period (01/07/2015 – 30/06/2016) an expected increase of +4.6 % (compared to 2014) as shown in Figure 26. The recorded data indicate a higher increasing, +14.6 %. The general high increase in total electrical consumption (+14.6 %

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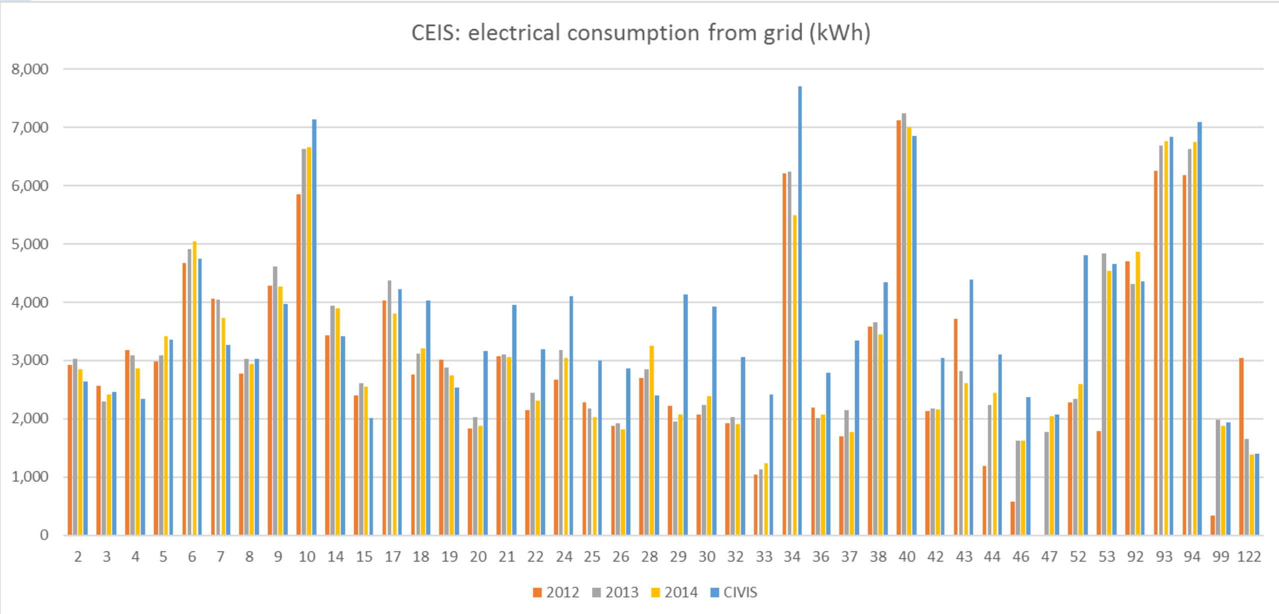
compared to 2014) is mostly due to the installation of new electrical appliances (dishwasher, dryer, electric hob, electric heater, ICT), supposed to be particularly accelerated in the period 2014 – 2015/2016.



	2012	2013	2014	CIVIS	trend 2014-2015/2016	% diff CIVIS-trend
kWh	125,771	137,043	134,813	156,478		
var %		9.0	-1.6	16.1	5.5	10.6

Figure 25 Electrical consumption from grid of CEIS participants in CIVIS project

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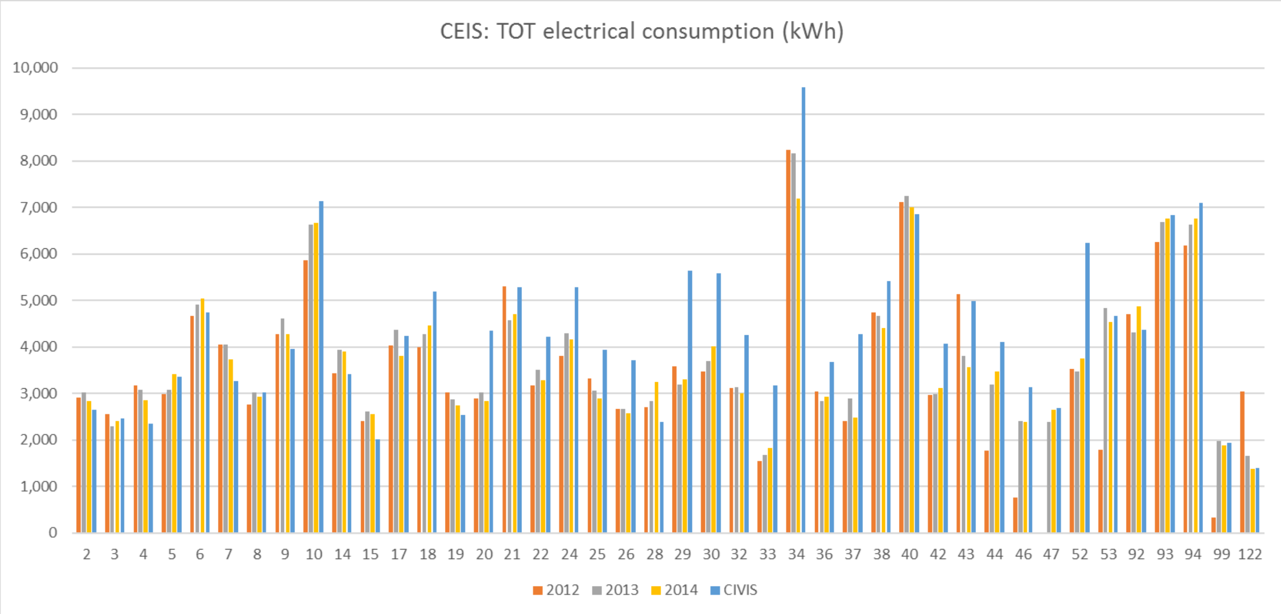

	2012	2013	2014	CIVIS	trend 2014-2015/2016	% diff CIVIS-trend
kWh	147,815	158,672	156,667	179,470		
var %		7.3	-1.3	14.6	4.6	10.0

Figure 26 Total electrical consumption from grid of CEIS participants in CIVIS project

In Summary for CEIS PV self-consumption (% of self-consumption of the PV self-produced) is increased for 11/21 of CEIS users comparing to 2014 and total electrical consumption (from grid and from PV self-consumption) is below the trend for half of CEIS users (21/42).

2.3.2 CEDIS

PV production is generally higher when compared to 2013 (5/6 users, CEDIS +3.0 %) as shown in Figure 27. This increasing can be attributed to more favourable conditions in solar radiation.

PV injection in CEDIS grid, compared to 2013, increased for 3/6 users and decreased for 3/6

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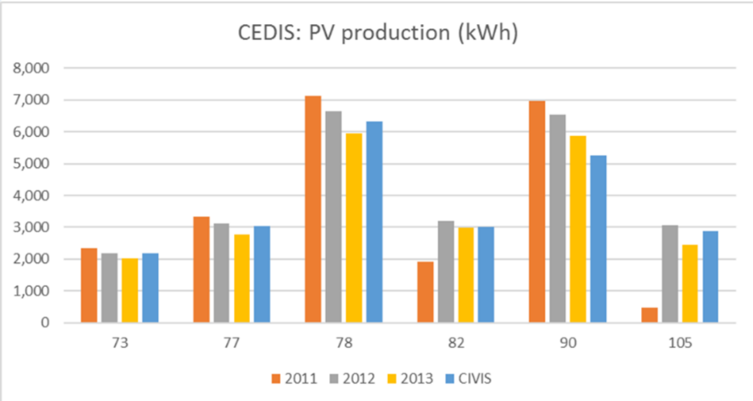
users (overall CEDIS -1.3 %) as shown in Figure 28.

PV self-consumption (% of self-consumption of the PV self-produced) increased for 4/6 of CEDIS users comparing to 2013 as shown in Figure 29**.** The % of PV self-consumption in CEDIS is around 29 %.



	2011	2012	2013	CIVIS
kWh	22,152	24,759	22,019	22,673
var %		11.8	-11.1	3.0

Figure 27 PV production of CEDIS participants in CIVIS project

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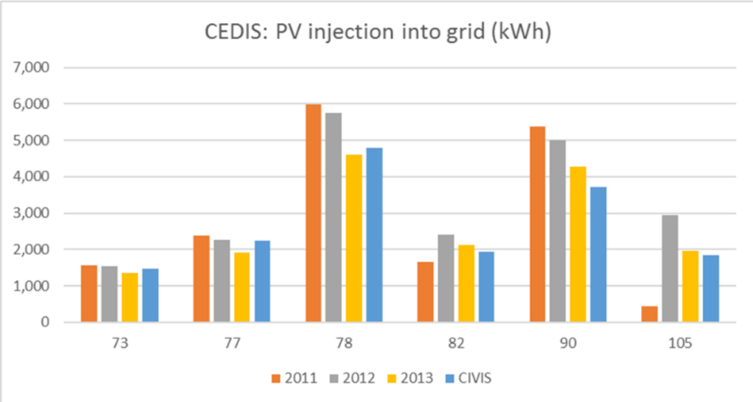
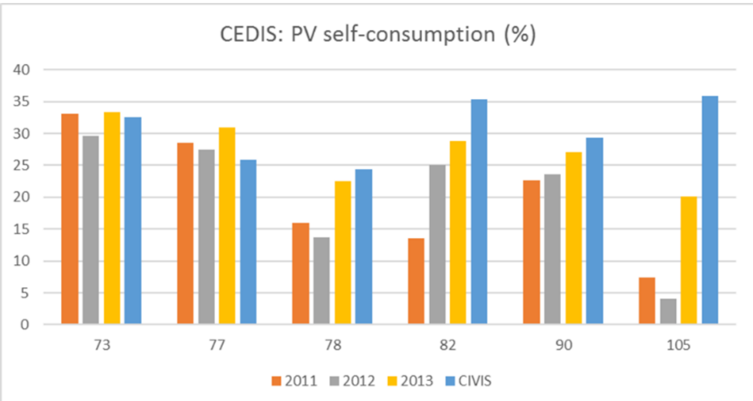


	2011	2012	2013	CIVIS
kWh	17,422	19,885	16,218	16,001
var %		14.1	-18.4	-1.3

Figure 28 PV injection into grid of CEDIS participants in CIVIS project



	2011	2012	2013	CIVIS
%	21.4	19.7	26.3	29.4

Figure 29 PV self-consumption (%) of CEDIS participants in CIVIS project

In CIVIS, considering the trend 2011-2013, **electricity consumption from grid is below the trend for 15/23 of CEDIS users**, for the other 8/23 is above as shown in Figure 30. In aggregate terms, **for the CEDIS consortium**, the trend during the three years 2011-2013

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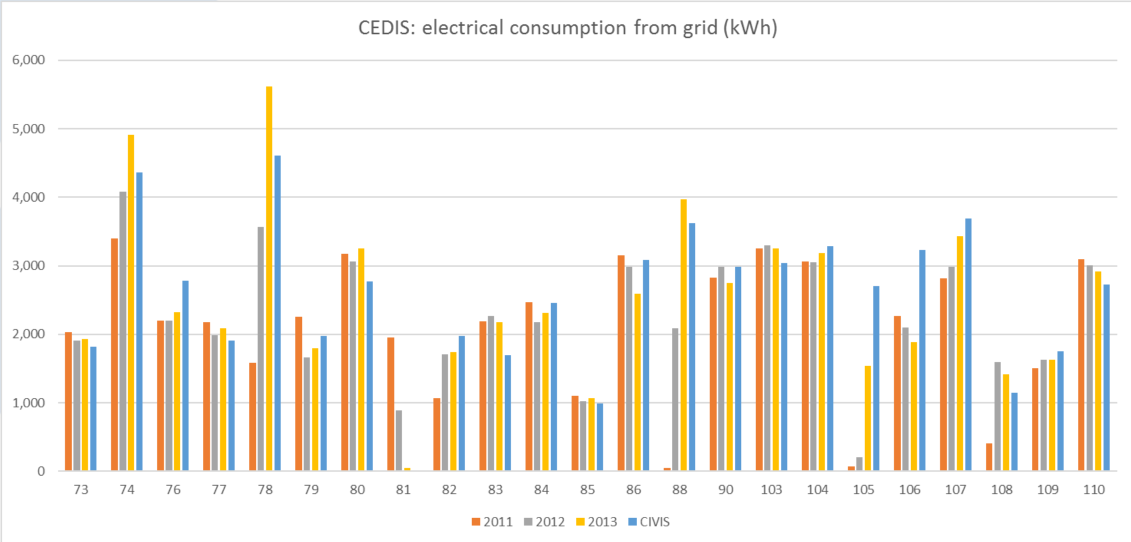
suggests for the CIVIS period (01/07/2015 – 30/06/2016) an expected increase of +24.3 % (compared to 2013). **The recorded data indicate a lower increasing**, +1.3 %.



	2011	2012	2013	CIVIS	trend 2013-2015/2016	% diff CIVIS-trend
kWh	48,060	52,411	57,837	58,573		
var %		9.1	10.4	1.3	24.3	-23.0

Figure 30 Electrical consumption from grid of CEDIS participants in CIVIS project

In CIVIS, considering the trend 2011-2013, **total electricity consumption (from grid and from PV self-consumption) is below the trend for 14/23 of CEDIS users**, for the other 9/23 is above. In aggregate terms**, for the CEDIS consortium**, the trend during the three years 2011-2013 suggests for the CIVIS period (01/07/2015 – 30/06/2016) an expected increase of +24.5 % (compared to 2013) as shown in Figure 31.

The recorded data indicate a lower increasing, +2.5 %. **This is an important energy saving result for the CIVIS period, a reduction of -22 % of total electricity consumption comparing to what expected by the historical trend, higher than what expected in CIVIS DoW (reduction potential in the range of 3-7% for the energy consumption).**

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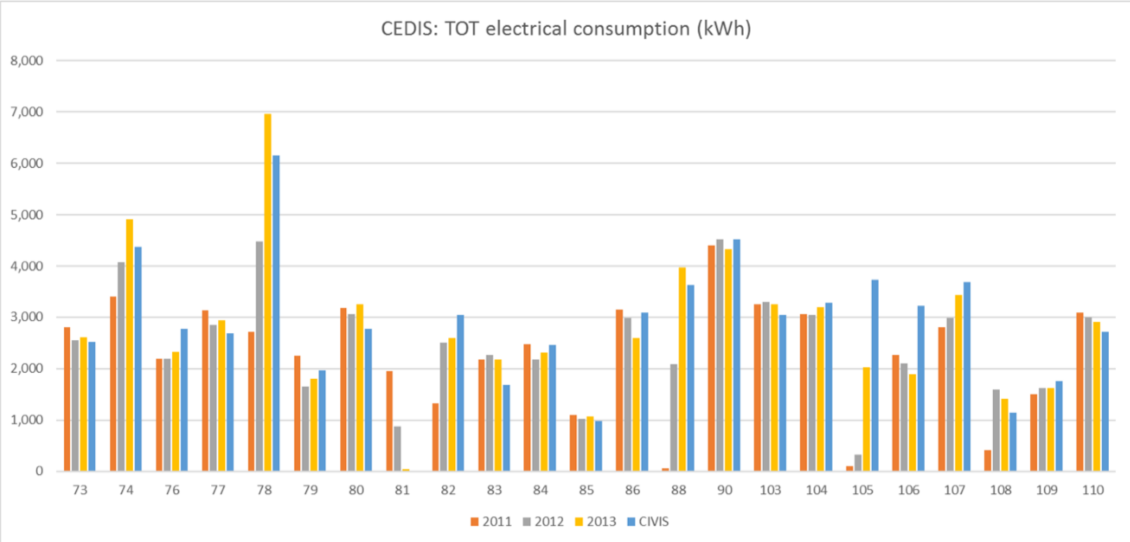

	2011	2012	2013	CIVIS	trend 2013-2015/2016	% diff CIVIS-trend
kWh	52,790	57,285	63,638	65,245		
var %		8.5	11.1	2.5	24.5	-22.0

Figure 31 Total electrical consumption from grid of CEDIS participants in CIVIS project

In Summary for CEDIS PV self-consumption (% of self-consumption of the PV self-produced) is increased for 4/6 of CEDIS users comparing to 2013 and total electrical consumption (from grid and from PV self-consumption) is below the trend for 14/23 of CEDIS users.

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2.4 Analysis of the thermal demand

To the question: "Have you performed actions to reduce energy consumption for heating?" CIVIS participants for the most part, about 65 %, declare "yes as before", a good percentage, about 15 %, "more than before" and only about 20 % "no" as shown in Figure 32. **CIVIS participants have therefore in general a positive attitude for energy saving (heating) and CIVIS project contributed for about 15 % of them to improve this good energy behaviour.**

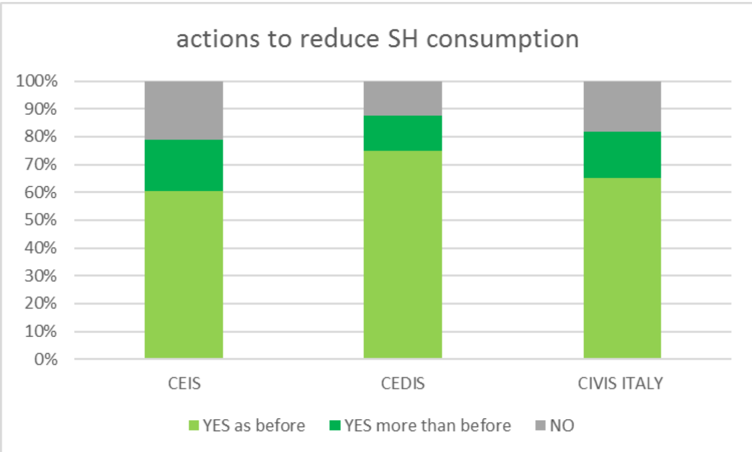

Figure 32 Results of the question "Have you taken measures to reduce space heating consumption?"

Concerning a quantitative analysis for the thermal demand are not available metered data. Moreover, the consumption data reported by CIVIS users in the Baseline Questionnaire and in the Final Questionnaire are not considered sufficiently reliable and accurate.

What is evaluated in the following paragraphs is the behaviour of CIVIS users against a standard for the indoor temperature and a space heating demand difference compared to that in the standard conditions.

Temperature data come from CIVIS sensors for the T indoor and Meteotrentino sensors for the T outdoor. Data for the evaluation of the space heating demand (conduction losses, ventilation & draughts losses, solar gain, internal gains) come from CIVIS d 7.2 (CIVIS Baseline Questionnaire, regulations).

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2.4.1 Outdoor temperatures in CEIS area and in CEDIS area

In CEIS the reference outdoor temperatures come from the weather station T0414 - San Lorenzo in Banale (Pergoletti). In Figure 33 the hourly values for the CIVIS period (01/07/2015 – 30/06/2016).

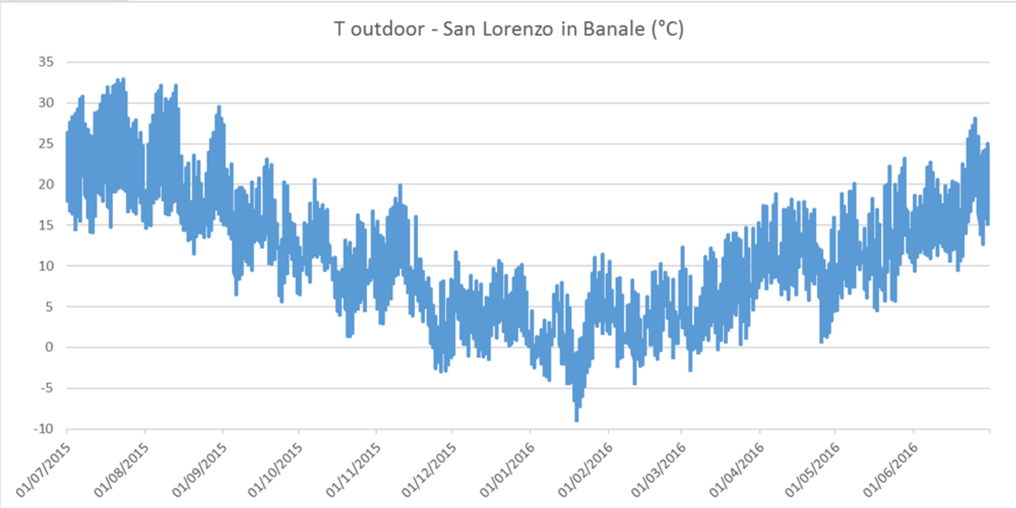

Figure 33 Hourly values of T outdoor in CEIS area. Weather station T0414 - San Lorenzo in Banale (Pergoletti)

In Table 8 are compared monthly data from Meteotrentino in the CIVIS period and average monthly data from PVGIS.

Table 8 Monthly values of T outdoor in CEIS area. Weather station T0414 - San Lorenzo in Banale (Pergoletti) and PVGIS

	T av	T max	T min	T av PVGIS
July	22.7	32.9	14.1	20.2
August	20.2	32.1	11.5	19.8
September	14.3	27.3	5.6	15.5
October	9.9	20.6	1.4	11.0
November	7.1	19.9	-3.0	5.7
December	3.9	11.7	-1.3	2.0
January	0.9	11.4	-8.8	1.6
February	3.0	10.5	-4.3	2.5
March	5.8	15.3	-2.7	6.1
April	10.6	18.8	0.8	9.5
May	12.4	23.2	4.6	14.4
June	16.8	28.1	9.4	18.3

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In CEDIS the reference outdoor temperatures come from the weather station T0393 - Storo. In Figure 34 the hourly values for the CIVIS period (01/07/2015 – 30/06/2016).

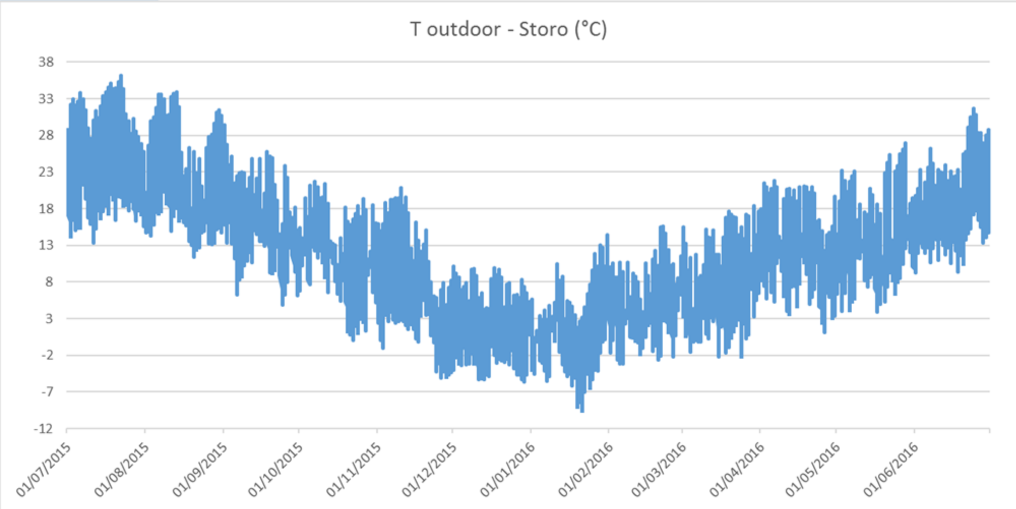

Figure 34 Hourly values of T outdoor in CEDIS area. Weather station T0393 - Storo

In Table 9 are compared monthly data from Meteotrentino in the CIVIS period and average monthly data from PVGIS.

Table 9 Monthly values of T outdoor in CEDIS area. Weather station T0393 – Storo and PVGIS

	T av	T max	T min	T av PVGIS
July	24.1	36.2	13.3	22.0
August	21.2	33.9	11.4	21.7
September	15.8	29.4	4.9	17.1
October	10.9	21.7	0.1	12.4
November	5.2	20.8	-5.1	7.3
December	0.1	10.1	-5.6	3.1
January	0.3	14.4	-9.5	2.0
February	4.3	15.6	-3.2	3.4
March	7.2	18.4	-2.2	7.3
April	12.3	21.8	1.1	11.1
May	13.9	26.9	3.9	16.1
June	18.3	31.7	9.3	20.1

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2.4.2 Indoor temperatures in CEIS area and in CEDIS area

Indoor temperatures are provided at an hourly resolution by CIVIS sensors. In Italy, 50 CIVIS families in CEIS area and 29 in CEDIS area are equipped with building indoor temperature sensors.
Considering the winter period (October – April) monthly average temperatures for each involved family, both in CEIS and in CEDIS area, are illustrated in Figure 35.

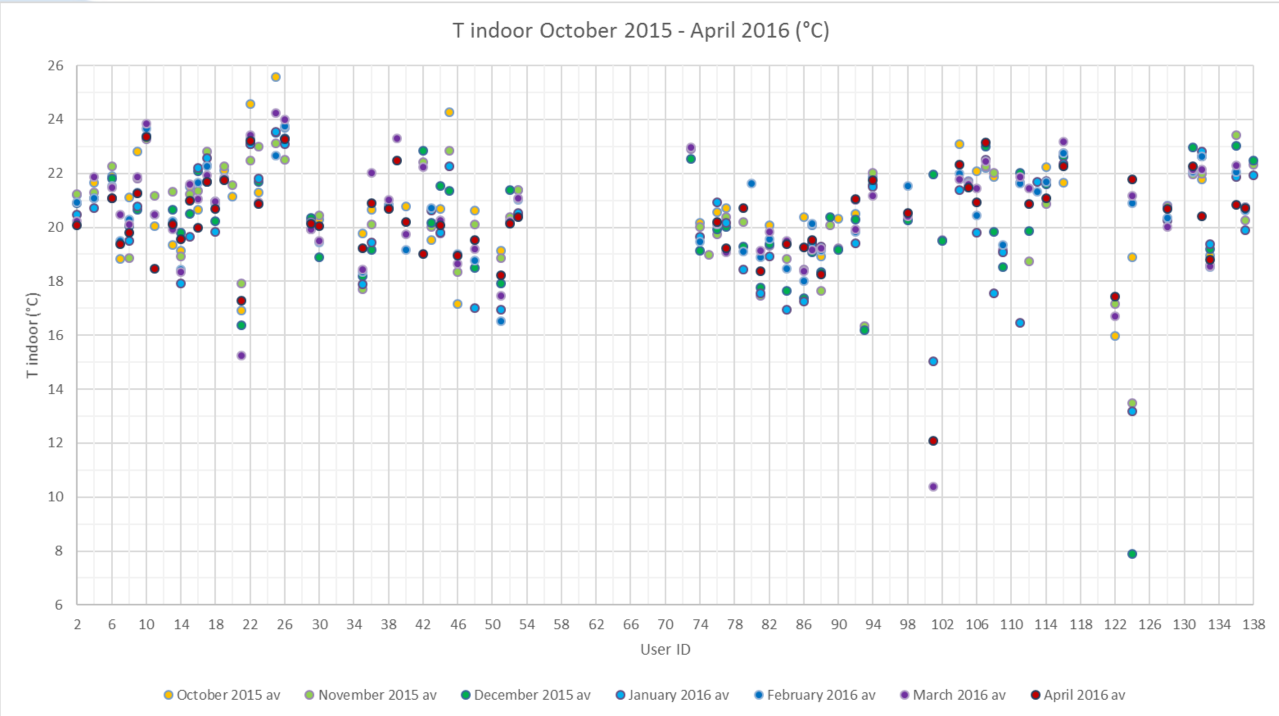

Figure 35 Monthly average temperatures for each involved family (CEIS and CEDIS)

The data show that in the CIVIS winter period (1 October – 30 April), on average, the thermal behavior of CIVIS users, in the control of T indoor, meets the recommended standard value of 20°C. Indeed, at consortium level, in CEIS the average temperature is 20.44 °C and in CEDIS 20.34 °C.

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2.4.3 Evaluation of overheating in CEIS area and in CEDIS area

An additional analysis considers the concept of **overheating**. The thermal status of a building is considered in overheating if the T indoor > 20°C during the daytime (5-23) and > 16°C during the night time (23-5), only if T outdoor < 12°C (need of space heating).

The individual % of hours in overheating are illustrated in Figure 36. Monthly consortium performance is reported in Table 10. **At consortium level, % hours in overheating are less in CEDIS (2.5 %) than in CEIS (15.2 %).**

Overall, in Italy, the use of temperature sensors and T indoor visualization helped a good control of space heating demand (SH demand) in CIVIS project (only an overall 11.4 % of hours in overheating).

Table 10 Monthly % hours in overheating for each consortium (CEIS and CEDIS) during CIVIS period (01/07/2015 – 30/06/2016)

	CEIS (%)	CEDIS (%)	CIVIS ITALY (%)
October	3.4	3.3	3.3
November	4.8	0.3	3.3
December	22.7	0.0	14.5
January	7.6	7.1	9.5
February	18.8	0.6	12.5
March	32.7	6.4	25.1
April	16.8	0.9	11.4
October 2015 - April 2016	**15.2**	**2.5**	**11.4**

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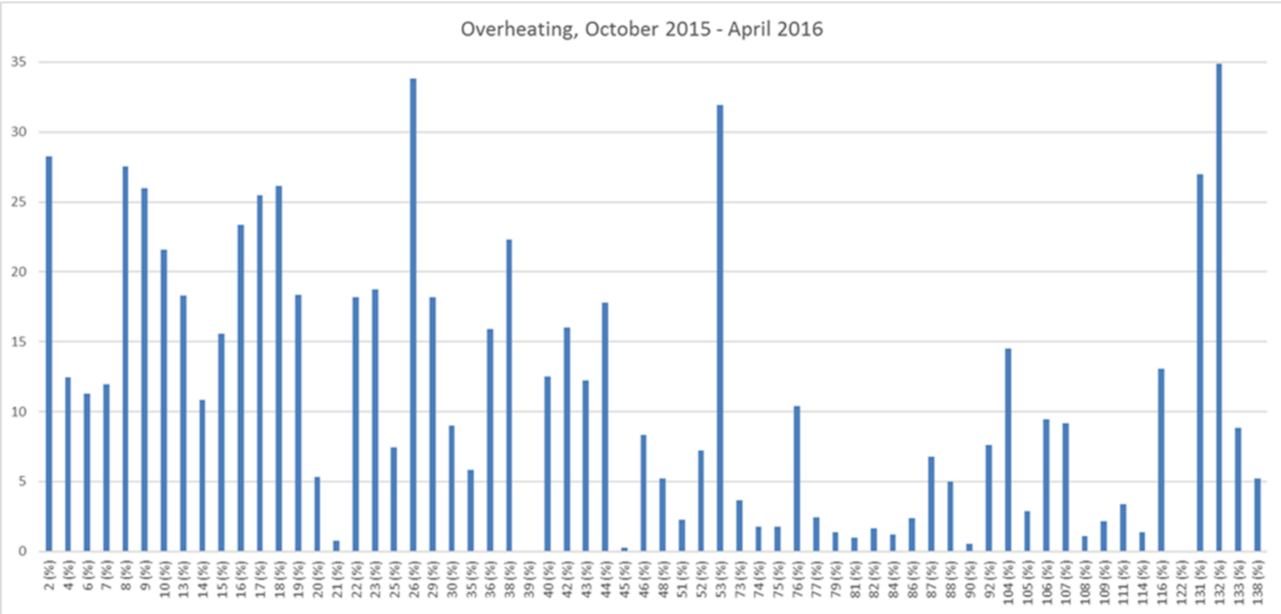

Figure 36 Percentage hours in overheating for each involved family (CEIS and CEDIS) during CIVIS period (01/07/2015 – 30/06/2016)

2.4.4 Space heating demand in CEIS area and in CEDIS area

For the space heating demand it is evaluated, at hourly resolution, during CIVIS period ,and for each CIVIS user, the % difference of the sum of demand for conduction (Q_t) and for ventilation & draughts (Q_v) in the standard indoor temperature (20°C) and in the real monitored indoor temperature.

In particular, for each hour:

$$Q_t = H_t * (T_{out} - T_{ind})$$

where H_t is the transmission heat exchange, individually evaluated in d 7.2, T_{out} the outdoor temperature (Meteotrentino), T_{ind} the indoor temperature (20°C in the first case and real monitored indoor temperature by CIVIS sensors in the second case).

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$$Q_v = H_v * (T_{out} - T_{ind})$$

where H_v is the transmission heat exchange, individually evaluated in d 7.2, T_{out} the outdoor temperature (Meteotrentino), T_{ind} the indoor temperature (20°C in the first case and real monitored indoor temperature by CIVIS sensors in the second case).

Individual results of this comparison (standard vs real T indoor), during CIVIS period (01/07/2015 – 30/06/2016), are reported in Figure 37.

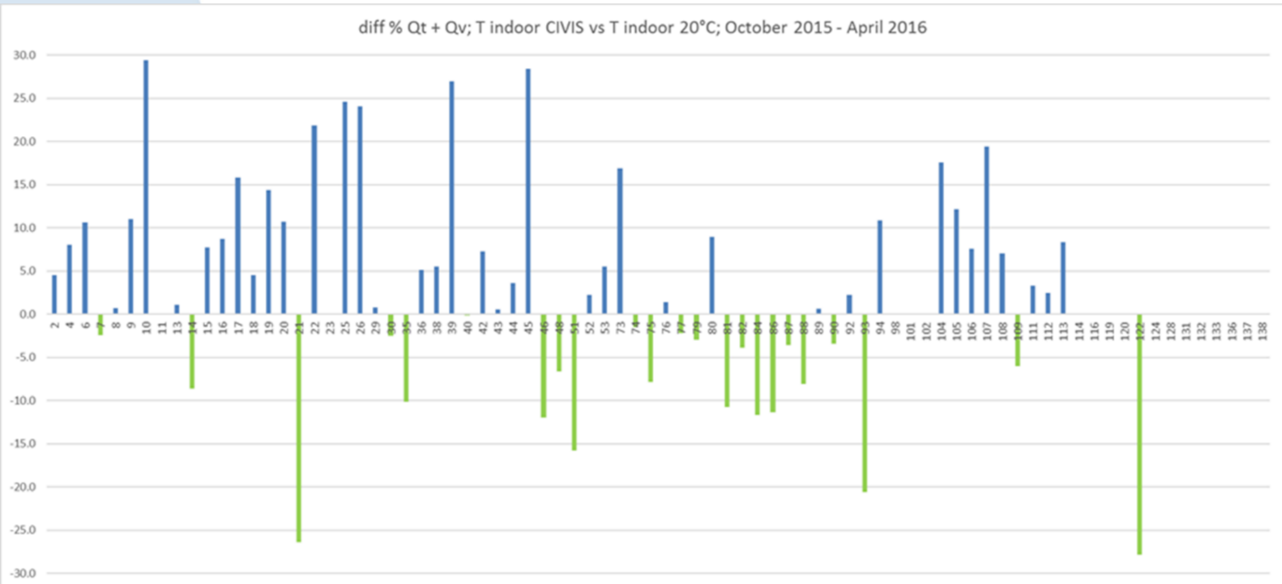

Figure 37 Space heating demand evaluation in CEIS and CEDIS (standard vs real T ind) during CIVIS period (01/07/2015 – 30/06/2016)

The data show that, in the CIVIS winter period (1 October – 30 April), on average the thermal behaviour of CIVIS users, in the control of space heating, meets the recommended standard values. Monthly consortium performance is reported in Table 11 (CEIS + 4.2% SH demand, CEDIS - 1.6% SH demand, CIVIS ITALY + 2.3%).

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Table 11 Monthly SH demand evaluation in CEIS and CEDIS (standard vs real T ind) during CIVIS period (01/07/2015 – 30/06/2016)

	Oct 2015 diff %	Nov 2015 diff %	Dec 2015 diff %	Jan 2016 diff %	Feb 2016 diff %	Mar 2016 diff %	Apr 2016 diff %	Oct 2015 - Apr 2016 diff %
CEIS	10.2	7.1	5.0	1.4	2.4	3.0	4.3	4.2
CEDIS	11.7	-0.8	-4.0	-5.0	-2.8	0.4	2.7	-1.6
TOT CIVIS ITALY	10.5	4.1	0.9	-0.9	0.8	2.4	4.0	2.3

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3 Evaluation of actions in Swedish Test site

3.1 Summary of actions carried out in Swedish Test site

In Hammarby Sjöstad test bed, two use cases were implemented. The first one is related to building level energy efficiency and the creation of a social network around that, while the second one focused on apartment-level energy efficiency. For the apartment level use case, the app has been deployed in two housing associations and the Smappee kits were deployed in 27 households, in order to get higher resolution consumption, data from appliances and control possibilities through smart plugs.

In Fårdala test bed, 10 households were equipped with Smappee kits in order to get higher resolution electricity consumption data, obtaining data about appliances consumption and control possibilities through smart plugs. Moreover, 30 households were equipped with Max EQ3 smart heating control systems, which will enable control of the heating system by the users. Figure 38 presents and overview of the actions carried out in the Swedish test site.

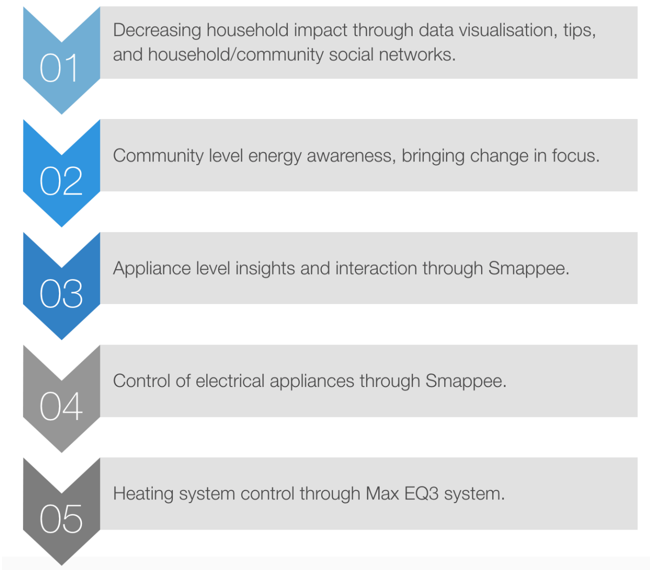

Figure 38 Summary of actions carried out in Swedish Test site

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It is important to mention that; with the MAX EQ3 system the users can change the temperatures inside the houses using the smart phone app or web portal. It also allows the users to set temperature profiles thus enabling them to lower the temperature during the night or when they are not at home.

3.2 Data collection and analysis

In view of the above mentioned interventions, the following parameter were collected and analysed with the purpose of evaluating the CIVIS measures.

- Heating (normalized for weather variations) and electricity data at housing association level in order to correlated it with different energy efficiency measures introduced in the building energy systems.
- App usage and social data through focus groups and interviews with the energy managers regarding the impact of the CIVIS platform.
- Individual electricity and (where applicable) hot water consumption data at household level.
- Smappee usage data, analysis of user's interaction with the system and impact assessment through interviews and follow up.
- Individual heating data (normalized for weather variations) in order to evaluate the impact of heating control through MAX eq3 control system.
- Evaluation of indoor temperature profiles set through MAX eq3 control system.
- Analysis of user's interaction with MAX control system through interviews and follow up with the users

Based on the above data collected, evaluation methodologies were selected to determine the impact of each intervention. This is summarized in Table 12.

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Table 12 Overview of evaluation methodology for various interventions in the Sweidish test site

Intervention	**Relevant Parameter(s)**	**Evaluation Methodology**
Visualization of housing association level energy data and energy measures implemented by other associations.	• Heating and electricity data including historical data. • Measures implemented. • Qualitative assessment of social interaction. • App usage data.	• Comparison between historical data and consumption data after implementation of measures (After normalization). • Interviews/focus groups with energy managers to gauge the impact.
Visualization of household level energy data and energy tips.	• Electricity and hot water consumption data. • App usage data.	• Comparison between baseline and data after deployment. • User interaction with CIVIS platform
Control and real time visualization of household electricity and appliance usage through Smappee.	• Electricity usage data. • Follow up with users • Smappee usage data	• Comparison between baseline and data after deployment. • User interviews/focus groups
Control of heating systems through MAX eq3 control system.	• Heating data • Follow up with users	• Comparison between baseline and data after deployment. User interviews/focus groups

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3.3 Hammarby Sjöstad Housing Associations Intervention

In Hammarby Sjöstad, data from 14 housing associations as shown in Table 13 was available and these were subsequently invited to join the CIVIS app starting from October 2015. At the finish of the project 8 out of the 14 housing associations had joined the project. The energy managers of the housing association were given a run through of the app. Various energy actions carried out by the association were added to the app by energy managers some of these actions are listed in Table 14.

*Table 13 List of BRFs where data collection for CIVIS took place with CIVIS users marked by**

BRF	Area (m2)	Apartments	Construction year	Ventilation type
Älven*	8231	69	2003	FVP
Grynnan*	10974	121	2004	F
Holmen*	12914	114	2002	FTX
Sjöportalen 1	8447	89	2003	FTX
Sjöstaden 1*	16616	167	2003	F
Sjöstadsviken	8349	83	2007	F
Strandkanten	3941	50	2004	F
Redaren	8072	104	2008	F
Sickla Kanal*	7706	66	2002	FTX
Seglatsen*	15692	137	2007	FVP
Slusstornet	9186	82	2004	F
Båtbyggaren 1	13535	135	2008	F
Hammarby Kanal*	4889	38	2002	F
Hammarby Ekbacke *	8405	60	2002	F

*Part of the CIVIS app

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Table 14 A sample of energy actions enerterd by the energy managers in the YouPower app.

BRF	Action	Time
Älven	Ventilation optimization	Aug-15
Grynnan	Lowered ventilation flow rate in the garage	Feb-13
	Outdoor ground heating turned off	Oct-12
Holmen	None	
Sjöstaden 1	Roof insulation	May-15
	Heat recovery heat pumps for ventilation	Feb-16
Sickla Kanal	Electricity metering in Laundry	Jan-15
Seglatsen	Heat recovery heat pumps for ventilation	Oct-14
	Individual metering for DHW	Nov-12
Hammarby Kanal	Ventilation optimization	
	Sub-metering for hot and cold water consumption	
Hammarby Ekbacke	None	

3.3.1 CIVIS app utilization

The primary focus of the CIVIS app (YouPower) in Hammarby Sjöstad was the energy managers of the housing associations. The app allowed the energy managers to monitor their energy use (heating and electricity), compare with previous year's consumption and the average consumption in the area and add energy actions carried out in housing association. Figure 39 presents a screen shot of the area populated with the housing association data. In terms of app usage two parameters the "cooperative actions expanded *(interaction with actions input by the energy manager) and "cooperative viewed" (interaction with the page showing energy data of cooperatives) is presented in Figure 40. Since this part of the app was oriented primarily towards the energy managers (8 users), the graph shows almost consistent interaction with the app since deployment in November 2015 till August 2016. The period between June and July is holiday season and hence the numbers are considerably lower.

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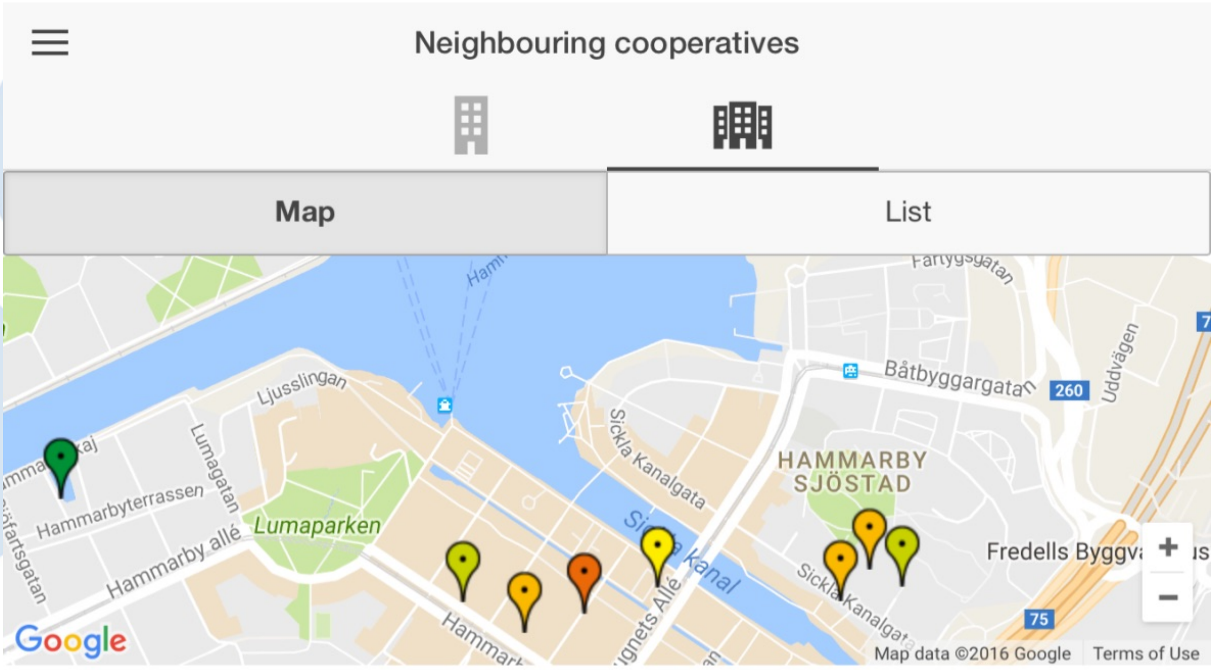

Figure 39 Screenshot of the CIVIS app in Hammarby Sjöstad populated by the active housing associations. The colors of the association is based on a scale of their energy consumption.

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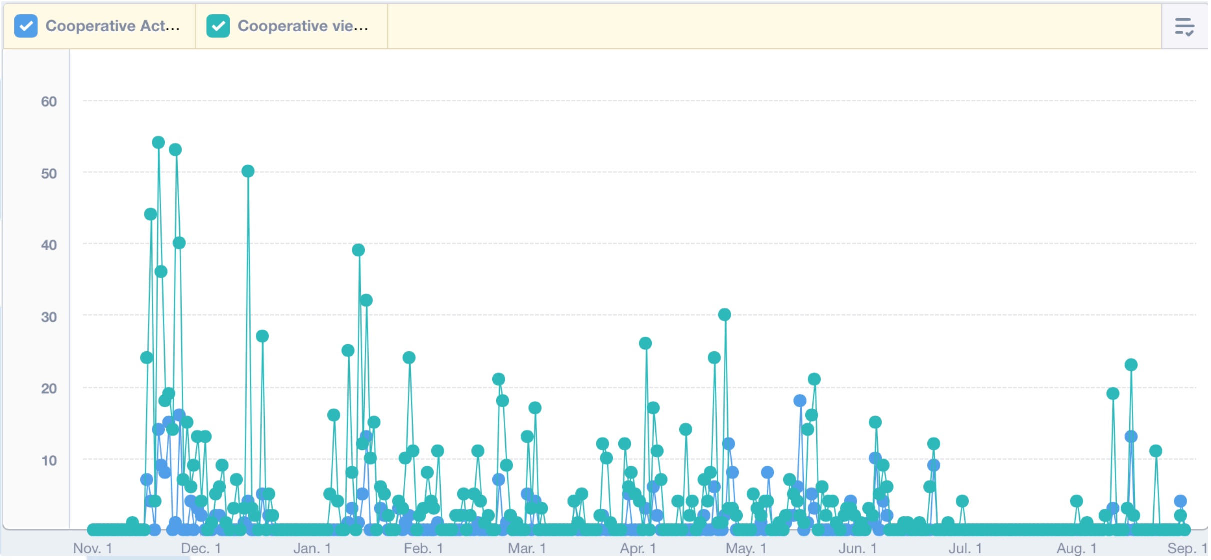

Figure 40 YouPower usage data for two parameters; the "cooperative actions expanded" and "cooperative viewed" (Nov 2015 - Aug 2016)

3.3.2 Energy Analysis

In order to carry out the energy analysis of the housing associations energy use the heating data was normalized for both weather variations as well as for area. For weather normalization, the methodology from the Swedish Metrological Agency was employed[6]. Temperature data for Stockholm from the Stockholm Environmental Administration[7] was used and degree days were subsequently calculated for the time period under study. The degree days are presented in Table 15.

[6] www.smhi.se
[7] www.slb.nu

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Table 15 Degree days for Stockholm for 2013-2016 compared with the "Normal Year" degree days.

	2016	2015	2014	2013	Normal Year
January	657,9	499,3	572,1	628,6	**519,2**
February	478,5	440,2	411,3	511	**485,3**
March	428,3	406,7	387,8	581,6	**546,6**
Quarter 1	**1564,7**	**1346,2**	**1371,2**	**1721,2**	**1551,1**
April	323,2	288,7	286,6	362,6	**326,2**
May	126,2	211,7	196,6	119,8	**250,8**
June	47,6	80,6	92,5	33,4	**0**
Quarter 2	**497**	**581**	**575,7**	**515,8**	**660,8**
July		28,8	5,8	9,4	**0**
August		1,3	40,4	12,7	**32,6**
September		104,4	102	122,6	**164,1**
Quarter 3		**134,5**	**148,2**	**144,7**	**221,7**
October		274,7	232,4	243,2	**344,1**
November		359,4	344,2	379,3	**416,8**
December		400,2	512	422,1	**533,0**
Quarter 4		**1034,3**	**1088,6**	**1044,6**	**1293,9**

Figure 41 presents the annual heating and hot water consumption data obtained from the DSO and normalized for weather variation and area for years 2012-2015. Data for the year 2016 being incomplete, the monthly data is presented later in Figure 43 and Figure 44. Similarly, Figure 42 presents the annual electricity consumption data for the housing associations for the years 2012-2015. In this case, one challenge has been the ability to separate the building services electricity from the total electricity consumption in some cases where the housing associations purchase both the electricity for the households as well as the building services electricity and the households are subsequently billed by the association. Therefore, in this case the electricity data for the housing associations Älven, Sjöstaden 1, Seglatsen and Sickla Kanal depicts the total electricity consumption while for the rest it depicts only the building services electricity and the households purchase their own electricity from the DSO.

From Figure 41 and Figure 42, housing association Älven, Grynnan and Seglatsen were able to

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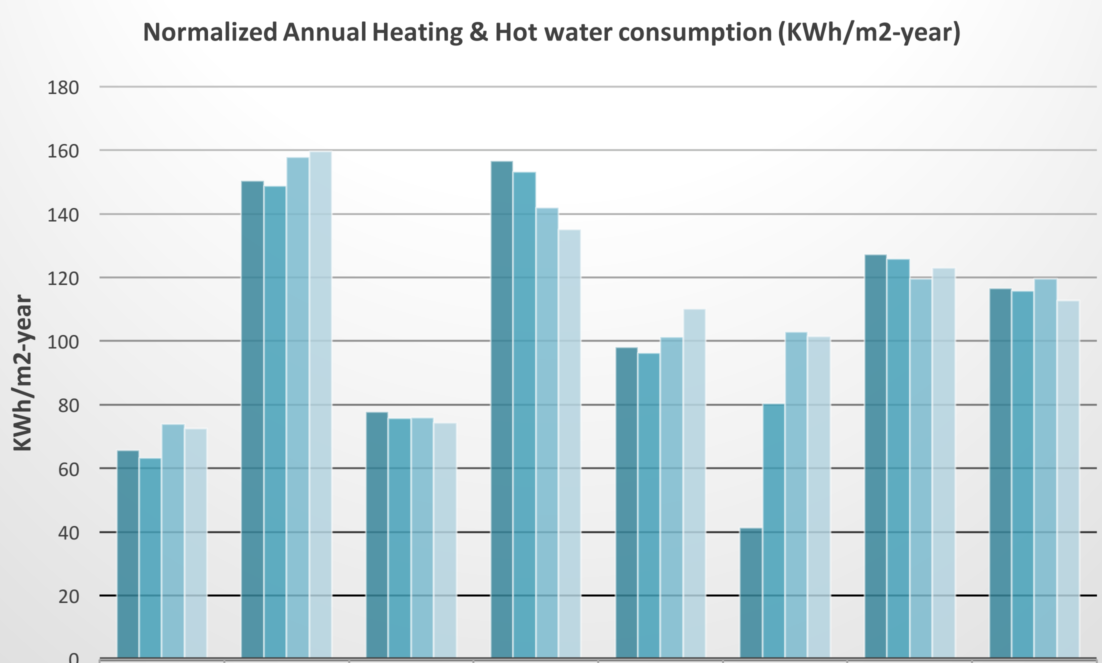
achieve considerable savings in heating consumption while associations Grynnan and Holmen were able to cut down on their electricity consumption. In case of Seglatsen there was an increase in electricity consumption due the installation of heat recovery heat pump. The actions carried out by the association are analysed further based on the monthly consumption data.



	Älven	Grynnan	Holmen	Sjöstaden 1	Sickla Kanal	Seglatsen	Hammarby Kanal	Hammarby Ekbacke
2015	65,7	150,5	77,8	156,6	98,1	41,4	127,2	116,5
2014	63,3	148,8	75,8	153,3	96,2	80,4	125,8	115,7
2013	74,0	157,8	76,0	141,9	101,2	102,9	119,6	119,5
2012	72,6	159,7	74,3	135,1	110,2	101,5	123,1	112,8

Figure 41 Normalized annual heating & hot water consumption data for CIVIS users (KWh/m2-year)

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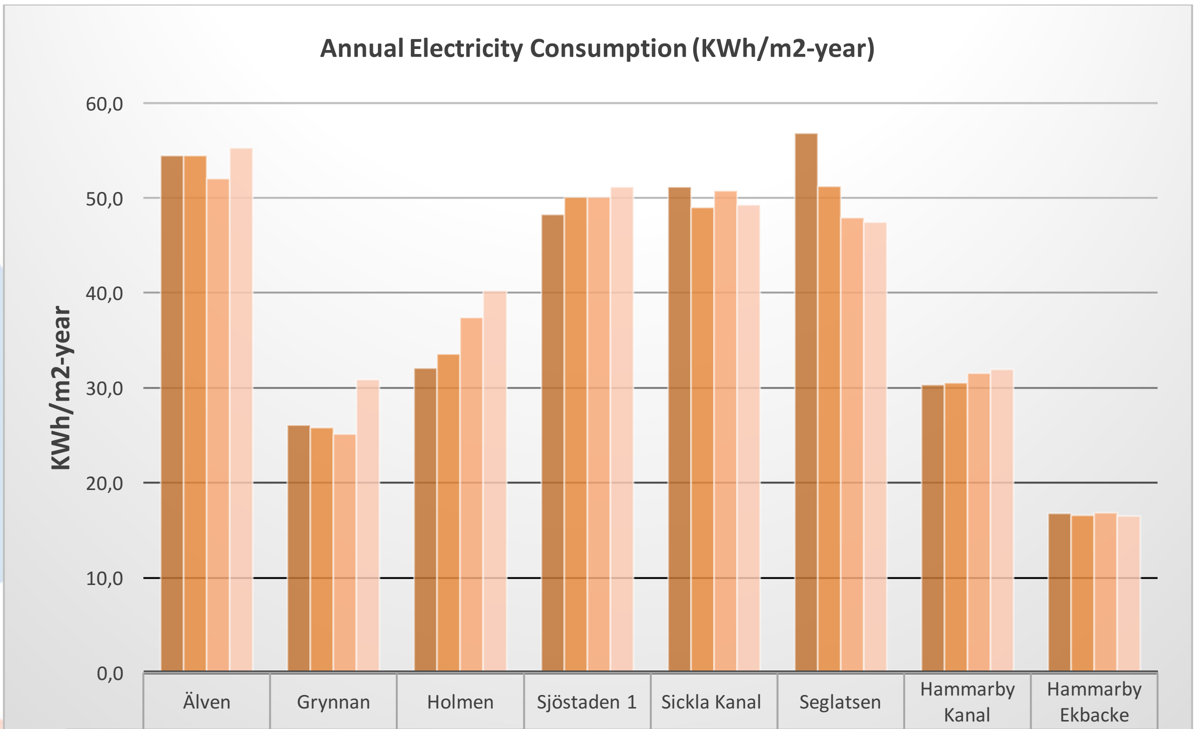

	Älven	Grynnan	Holmen	Sjöstaden 1	Sickla Kanal	Seglatsen	Hammarby Kanal	Hammarby Ekbacke
2015	54,4	26,1	32,1	48,2	51,2	56,8	30,3	16,8
2014	54,4	25,8	33,6	50,1	49,0	51,2	30,5	16,5
2013	52,0	25,1	37,4	50,1	50,7	47,9	31,5	16,8
2012	55,2	30,8	40,2	51,2	49,2	47,4	32,0	16,5

Figure 42 Annual electricity consumption data for CIVIS user associations (2012-2015) in KWh/m2-year

Figure 43 and Figure 44. present the total monthly consumption for heating and electricity (in MWh) from January 2014 to August 2016 to study the impact of the actions carried out in details for some of the housing associations.

- **BRF Älven:** Ventilation optimization was carried out in August 2015, however the energy use went up. This motivation for carrying out the optimization was issues related to lower thermal comfort and as a result a slight increase in energy consumption can be noticed in both heating and electricity.

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- **BRF Grynnan:** In this case, there are reductions in heating in 2016 due to adjustments of ventilation system as well in electricity due to turning off the outdoor ice melting system.
- **BRF Sjöstaden 1:** In this association, extra insulation was added to the roof of the buildings in May 2015 which lead to a decrease in heating consumption. However, major savings were accomplished due to the installation of heat recovery heat pumps in February 2016. This lead to some increase in electricity consumption but the overall impact is prominently positive.
- **BRF Seglatsen:** This housing association accomplished the largest savings by installing recovery heat pumps in the building, reducing the heating consumption by around 60%. Overall considering the rise in electricity consumption the cost savings per year amount to about 40% of the total.
- BRF Hammarby Kanal: was able to accomplish some savings based on ventilation optimization.
- **BRF Hammarby Ekbacke:** Even though not mentioned in the actions in the app, this association has been piloting "Goal based energy reduction" program with Dalkia for improving the energy system with visible savings since the end of 2015. The program offers a new business model to the housing associations where part of the savings goes to the ESCO for a fixed time period, while the housing association avoids having to pay upfront costs for the actions.

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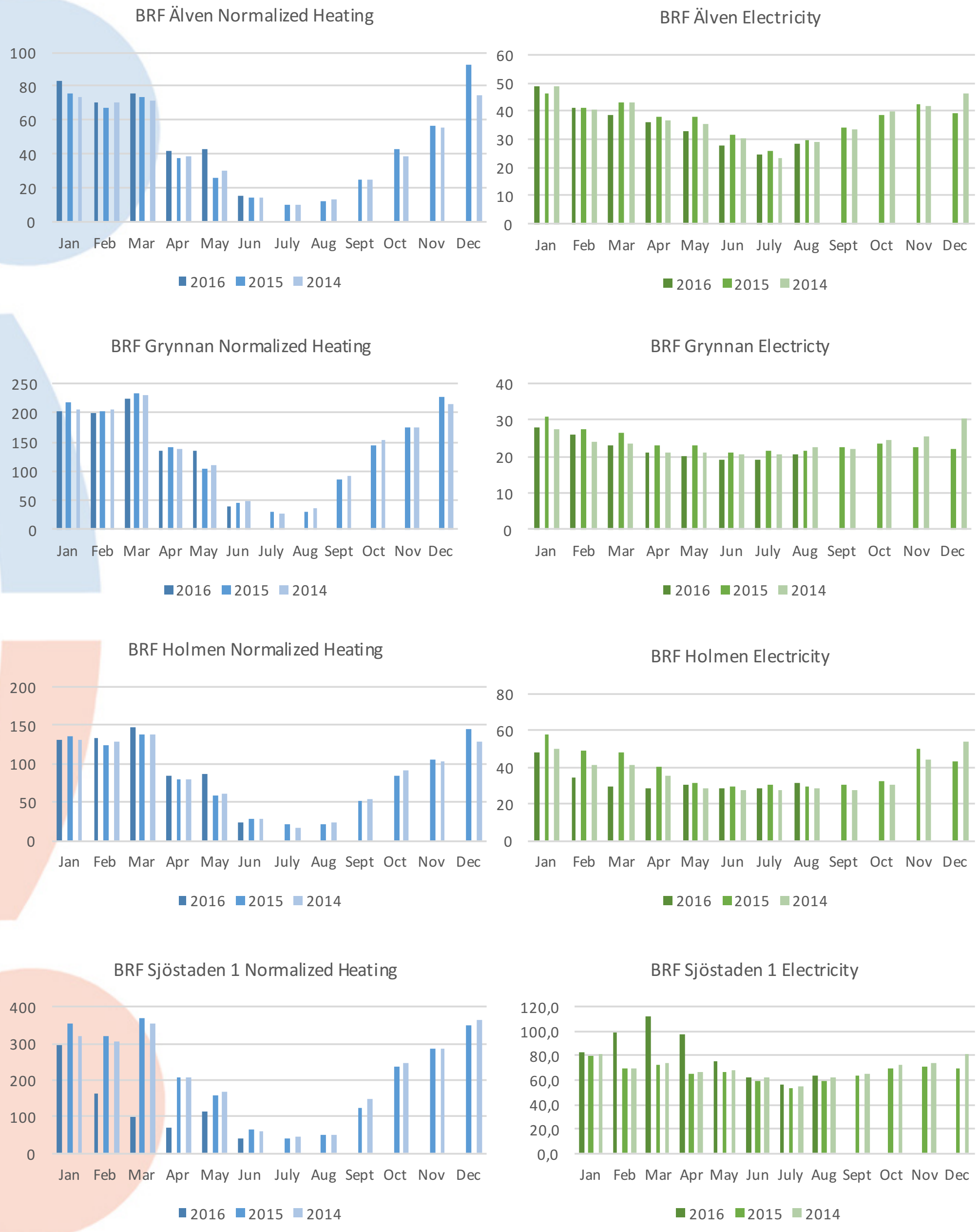

Figure 43 Monthly normalized heating (MWh) and electricity (MWh) data for housing associations Älven, Grynnan, Holmen and Sjöstaden 1 for 2014-2016

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Figure 44 Monthly normalized heating (MWh) and electricity (MWh) data for housing associations Seglatsen, Sickla Kanal, Hammarby Kanal and Hammarby Ekbacke for 2014-2016

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3.4 Household Energy Visualization and Tips App in Hammarby Sjöstad

The CIVIS YouPower app for households was deployed in two housing association in Hammarby Sjöstad. In BRF Seglatsen, 137 households were invited to join the project out of which 36 households signed up to the app. In BRF Grynnan, 121 households were invited out of which 10 households signed up. The data from 137 households in Seglatsen has been monitored for last 13 months in order to study the patterns of consumption. Figure 46 and Figure 47 present the household electricity and domestic hot water consumption data categorized according to the size of the apartments. On average the consumption increased with the size of the apartments, however in the case of 5 room apartments it was lower for electricity than the 4 room apartments and for hot water all the rest. This anomaly was investigated and the reason was it was primarily households with older children who had already moved out of the parents' houses leading to a lower consumption.

Avg. consumption	1 room	2 room	3 room	4 room	5 room
Electricity (KWh)	148,7	180,7	275,0	328,7	280,1
Hot water (m^3)	1,8	1,6	2,4	3,0	1,3

Another interesting aspect visible in the data was considerably higher consumption during the winter season. This increase was substantially higher than the expected increase due to higher use of lighting during the winter. On investigation this was attributed to the use of floor heating in the bathrooms in the larger apartments.

The app usage statistics for the household part are presented in Figure 45. Since the deployment in November 2015 the app usage was considerably high which subsequent spikes occurring periodically. The app usage data has been further analysed in D5.3.

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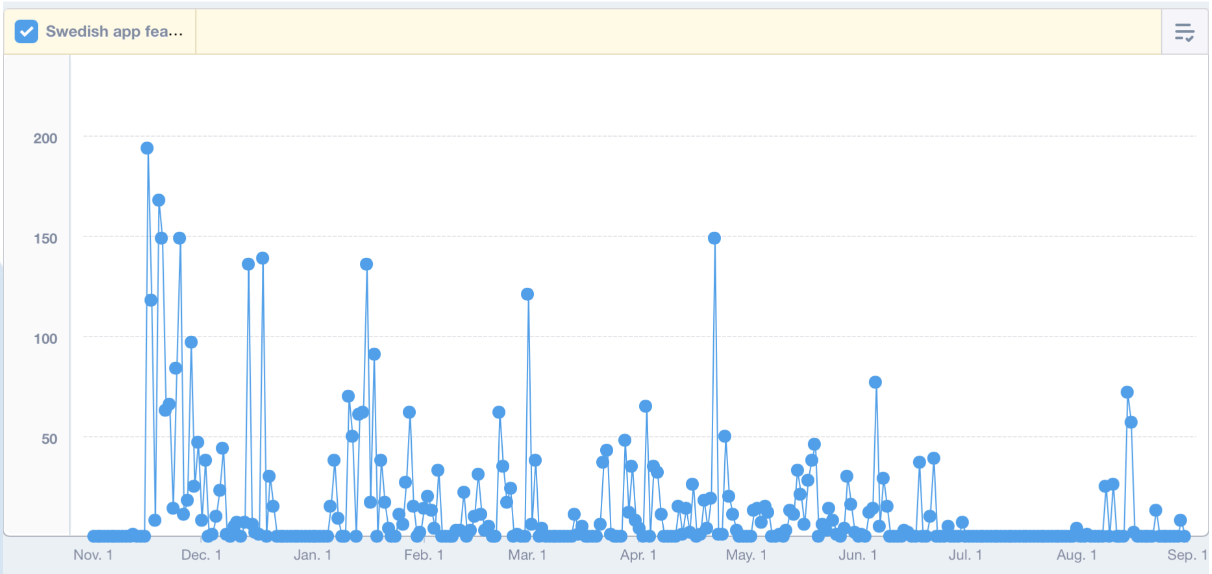

Figure 45 App usage data for household part of YouPower app.

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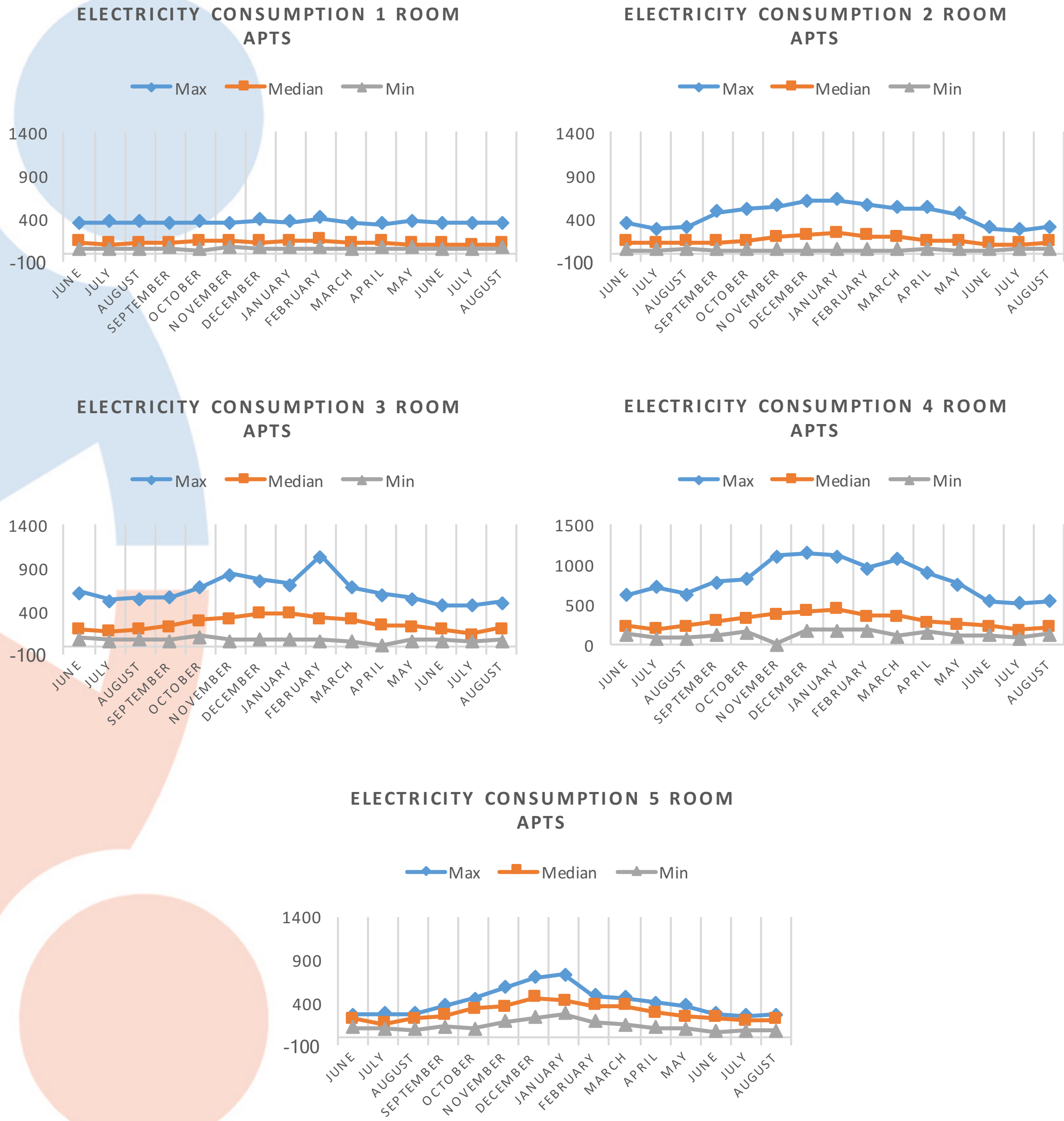

Figure 46 Min, Max and Median electricity consumption in 137 apartments in BRF Seglatsen grouped by size of apartments (KWh) from June 15 - August 16

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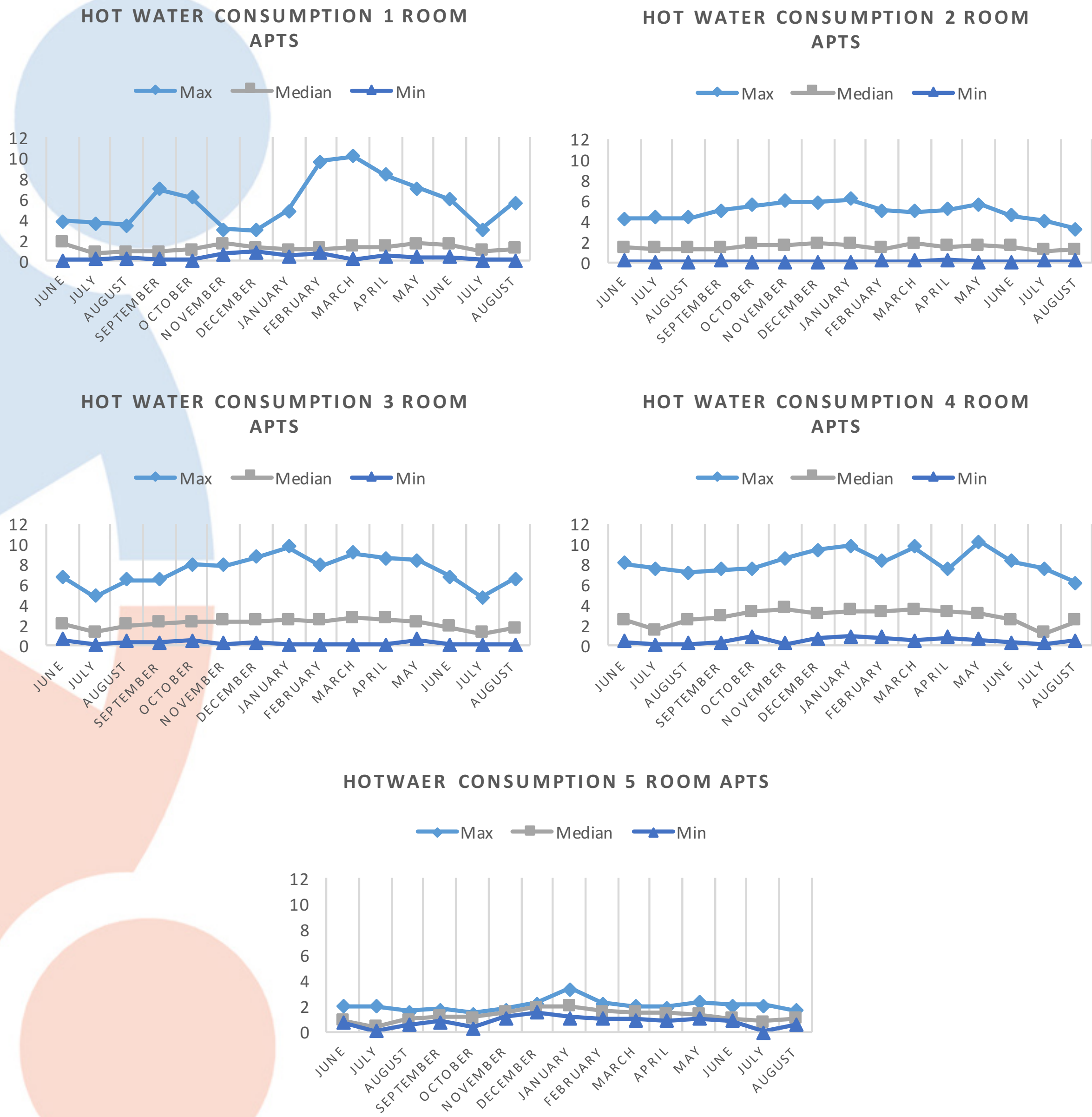

Figure 47 Min, Max and Median domestic hot water consumption in 137 apartments in BRF Seglatsen grouped by size of apartments (m3) from June 15 - August 16

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The energy consumption of the users for the household part of Youpower app are presented in Figure 48 and Figure 49 where the red horizontal lines depicting the time of deployment. However, no direct savings are visible in the energy data in the case of BRF Seglatsen users. This analysis is further complicated but the limitation of only 13 months of data availability and the high seasonal variation of consumption. Similarly, in the case of the users in Grynnan slight savings are visible in some of the users.

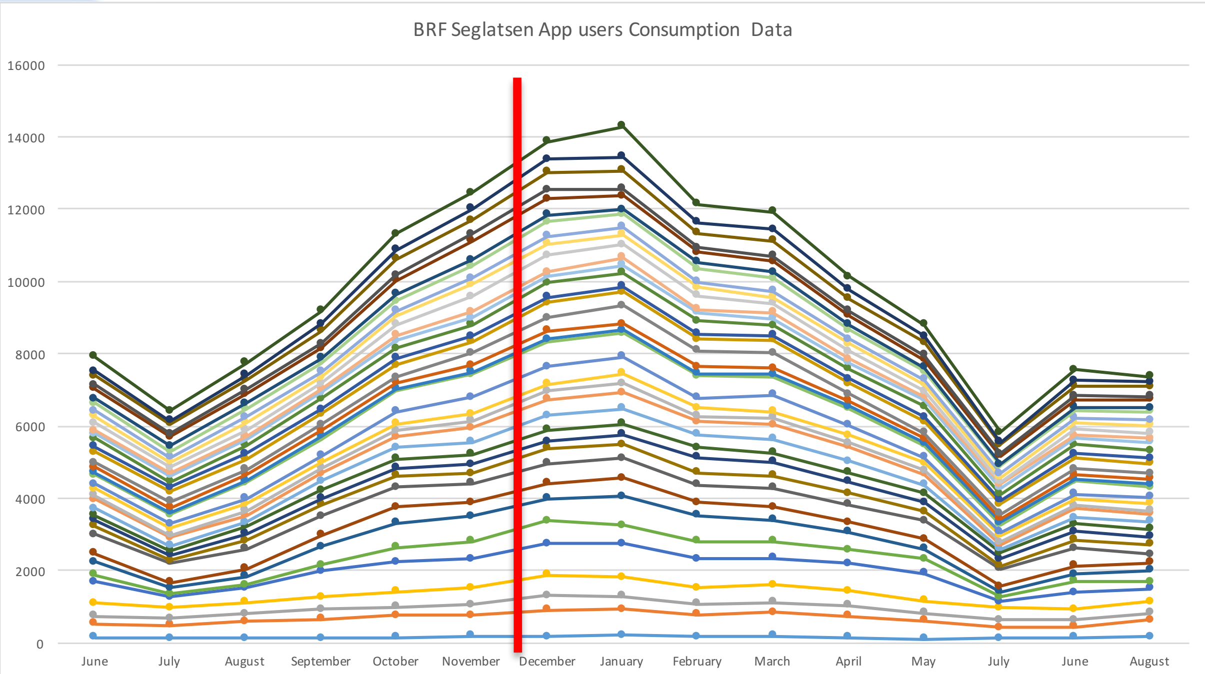

Figure 48 Electricity consumption profiles (KWh) for YouPower users in BRF Seglatsen June 2015 - August 2016 with red vertical line showing the time of deployment.

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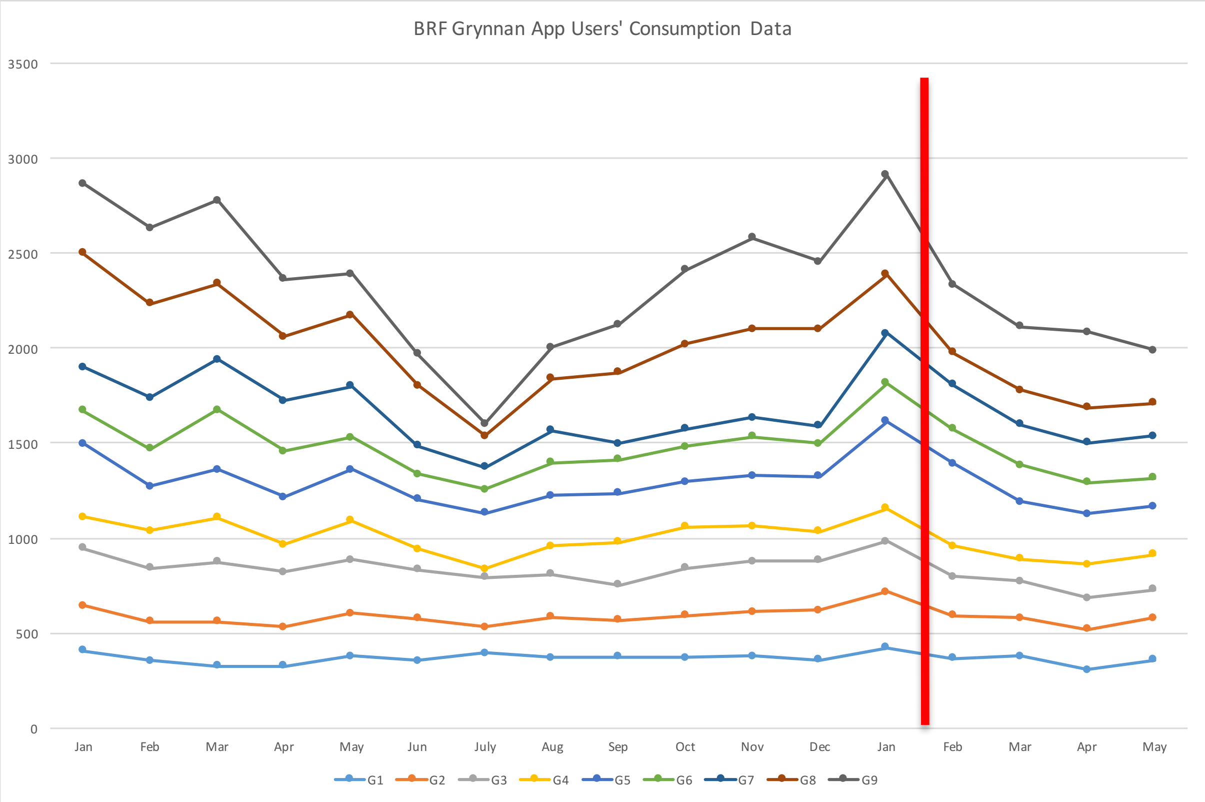

Figure 49 Electricity consumption profiles (KWh) for YouPower users in BRF Grynnan Jan 2015 - Aug 2016 with red vertical line showing the time of deployment.

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3.5 Smappee

In total 27 households (10 in Fårdala and 17 in Hammarby Sjöstad) were equipped with smart energy monitors (SMAPPEE) to provide high resolution (5 min) electricity usage data. The device recognizes the main appliances in the household and allows the users label them and keep track of their consumption. Additionally, each household was provided with 7 smart plugs that allow control of appliances remotely.

The energy consumption data and interaction data for the households was analysed and follow up interviews were subsequently conducted to determine the impact of the system. The consumption data for households in Fårdala is presented in Figure 50. Two households eventually dropped out of the study in February and April hence partial data is available. Overall in Frådala, some minor savings were observed in the results.

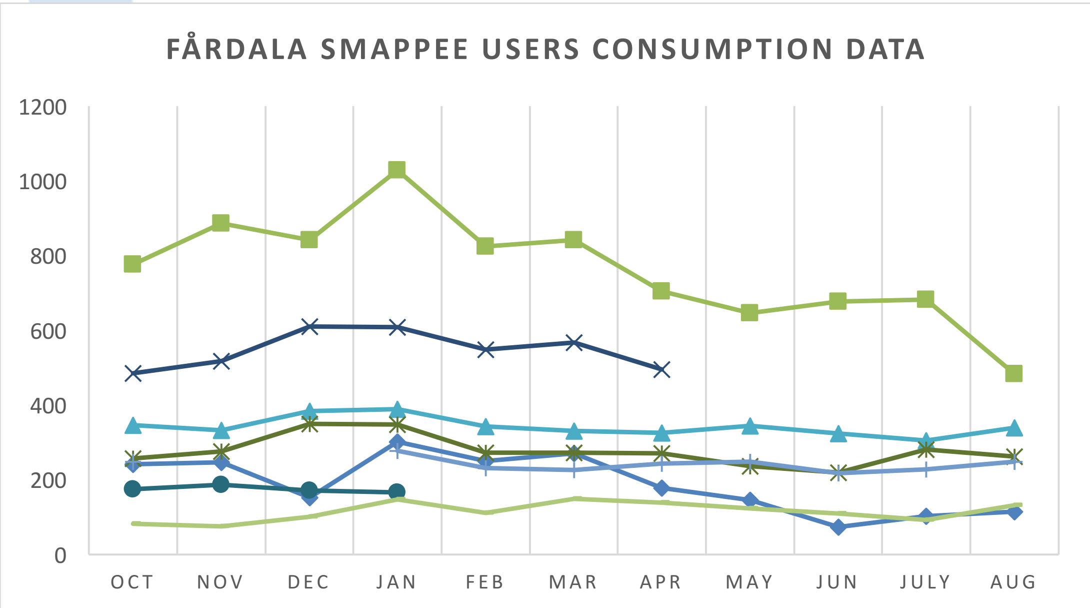

Figure 50 Smappee users' consumption data in Fårdala (KWh)

In Hammarby Sjöstad, the results (as shown in Figure 51 were less clear and no particular patterns emerged. However, some users were able to achieve savings during the study period. The results can be further explained by studying the interaction data for the Smappees installed. For this purpose, the number of appliances labelled and the number of smart plugs

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in use by the households was studied as shown in Figure 52. Overall, five users didn't manage to label any appliances, while 6 users were able to label more than 10 appliances. It must be noted that the total number of appliances shown here doesn't represent the total appliances at home, as Smappee at times treats for example each hot plate in the stove as a separate entity. In terms of smart plugs, 8 users installed 3 or more plugs.

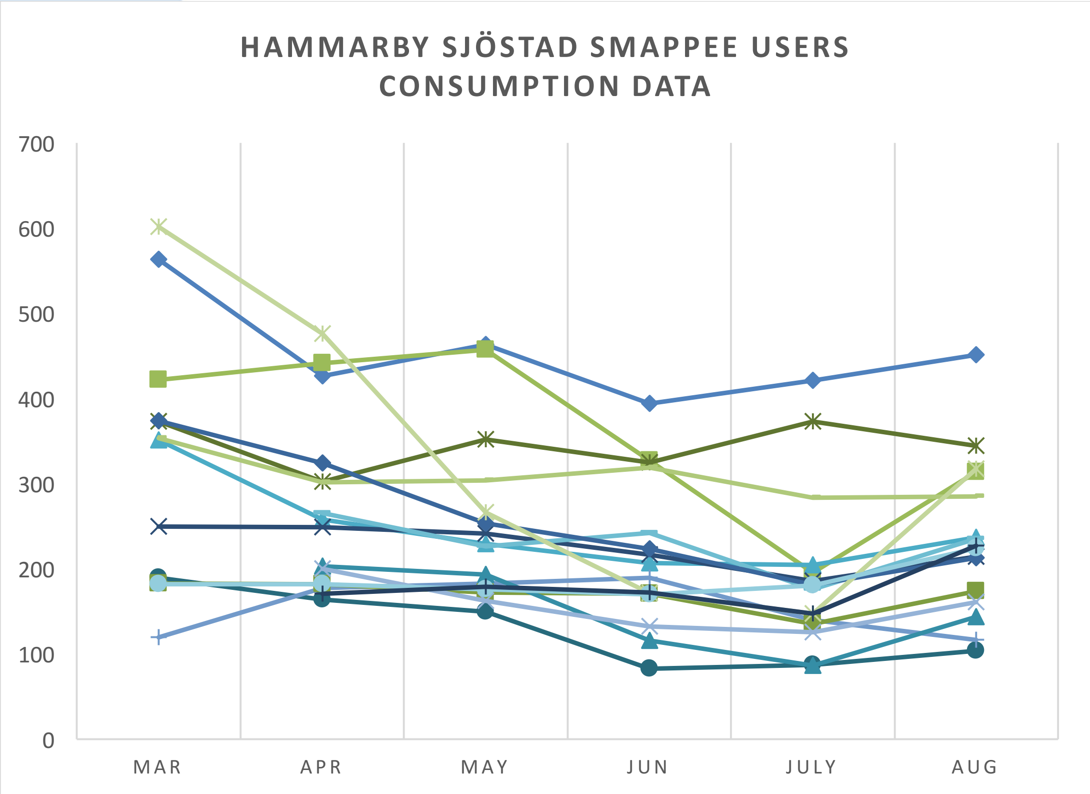

Figure 51 Smappee users' consumption data in Hammarby Sjöstad (KWh)

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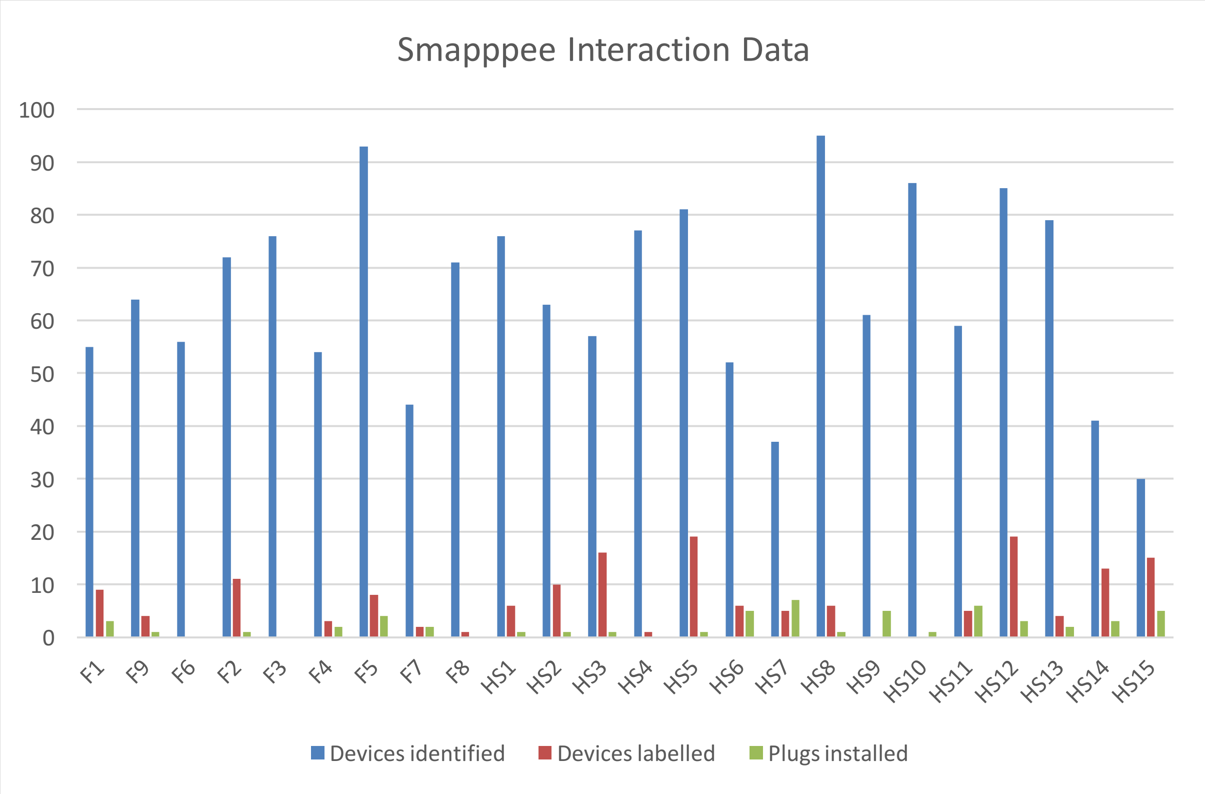

Figure 52 No. of appliances detected, labelled and no of plugs installed.

3.5.1 Interview with Smappee users

In order to better understand the households experience with Smappee 15 interviews were held in total, 6 in Fårdala and 9 in Hammarby Sjöstad. On average each interview lasted about 45 minutes some of the key findings of the study are:

- In general, the respondents had a good initial impression of Smappee especially because they could instantaneously monitor their consumption. Some of the users were confused about how the system worked and had some frustration about labelling the appliances.
- One thing that almost all participants had in common was that they said that labelling appliances in Smappee was too hard. 5 participants had not even tried to label an

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appliance and one of them had not even understood that Smappee was able to detect individual appliances. 2 of the 15 participants had labelled one appliance but said that they made a mistake when they did that. The rest of the participants (8 of the 15) had tried to label as many appliances as possible but stopped when they either made a mistake or because they felt that it was too hard or when they did not think it was worth it.

- Users who had labelled some appliances did that during the first couple of weeks. They said that they thought it was fun to walk around and hunt appliances in the house. But they stopped doing that later on, either because they had labelled the ones that were obvious to them, or because they thought it was, in general, too hard to continue.
- Only two of the participants used Smappee on a regular basis, the two of them used it many times a day. The others had used it many times a week during the first couple of weeks but then started to look at Smappee more rarely.
- Most of the participants used the main screen, where their real-time consumption and their always-on consumption displays, most frequently. They looked at the real-time consumption in order to get an overview if everything looks correct according to them.
- The plugs that are delivered with Smappee were not used that frequently in apartments. A common thought of the users who live in apartments is that they are more suited for houses with two floors, where you can turn things off at the other floor and you will not have to walk a long distance to do that.
- Almost all of the participants said that they could not change the way they use most of their appliances since the appliances fill a practical purpose. However, a little bit less than half of the participants had in some small way changed their consumption behaviour due to Smappee.

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3.6 MAX Heating Control System

Additionally, in 30 households a smart heating control system was deployed enabling users to control the indoor temperature by offering control of radiator thermostat valves (MAX eq3) through smart phone or web portal. The system also allows for collection of indoor temperatures in the houses. Figure 53 shows the typical installation configuration in Fårdala where several thermostats/rooms are grouped together with the wall thermostat and some rooms such as storage were configured independently to allow flexibility of use. The users in general were consulted during the configuration process. The users can then set weekly temperature profiles. The temperature profiles have been recorded and are being analysed. Figure 55 shows the analysis of indoor temperatures in different part of the house set by users during the weekdays and weekends.

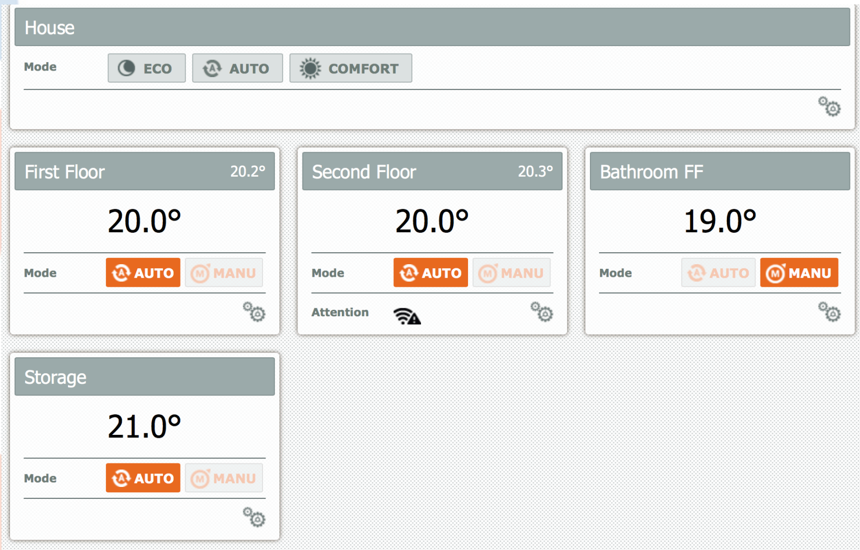

Figure 53 Typical installation configuration for Max heating control system in Fårdala.

The installation of the Max system was carried out starting December 2015. The heating data from the households was normalized in order to measure the impact. The data was compared with the normalized corresponding quarters data from previous years which served as a baseline for comparison. The data for the households is presented in Table 16. the table has been divided into three areas of Fårdala Eken, Vallen and Tallen due to the difference in types

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of houses. Figure 54 shows the percentage chance in energy consumption in the households for both quarters after installation of Max system compared to the baseline. Overall for the first quarter 8% savings on average were achieved while for the second quarter it was 17% on average. In some cases, there was an increase in the heating consumption. This was due to the fact that the households had completely shut off the radiator valves in some part of the house and due to installing Max these were set according to the universal profiles chosen by the users.

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Table 16 Normalized heating data for Q1 and Q2 2016 along with corresponding average baselines (KWh).

ID	Year	Quarter	Heating	Normalized	Quarter	Heating	Normalize
E1	**2016**	**1**	**4298**	**4261**	**2**	**568**	**755**
E1	Avg B	1		3236	2	700	1189
E2	**2016**	**1**	**5964**	**5912**	**2**	**1676**	**2228**
E2	Avg B	1		6384	2	2230	2547
E3	**2016**	**1**	**3539**	**3508**	**2**	**771**	**1025**
E3	Avg B	1		3483	2	577	1026
E4	**2016**	**1**	**4783**	**4741**	**2**	**1812**	**2409**
E4	Avg B	1		5011	2	2089	2315
E5	**2016**	**1**	**4510**	**4471**	**2**	**1444**	**1920**
E5	Avg B	1		4761	2	1500	1783
E6	**2016**	**1**	**4555**	**4515**	**2**	**1392**	**1851**
E6	Avg B	1		3910	2	1167	1643
E7	**2016**	**1**	**4180**	**4144**	**2**	**1999**	**2658**
E7	Avg B	1		4243	2	1640	1753
E8	**2016**	**1**	**2406**	**2385**	**2**	**382**	**508**
E8	Avg B	1		3298	2	1282	1521
E9	**2016**	**1**	**5020**	**4976**	**2**	**1223**	**1626**
E9	Avg B	1		5600	2	1979	2354
E10	**2016**	**1**	**3229**	**3201**	**2**	**626**	**832**
E10	Avg B	1		3211	2	889	1163
E11	**2016**	**1**	**4184**	**4148**	**2**	**1004**	**1335**
E11	Avg B	1		5269	2	2154	2337
V1	**2016**	**1**	**9105**	**9026**	**2**	**2646**	**3518**
V1	Avg B	1		9535	2	3502	3496
V2	**2016**	**1**	**7480**	**7415**	**2**	**1862**	**2476**
V2	Avg B	1		6880	2	1738	2163
V3	**2016**	**1**	**7717**	**7650**	**2**	**2176**	**2893**
V3	Avg B	1		7748	2	2482	2965
V4	**2016**	**1**	**6705**	**6647**	**2**	**1952**	**2595**
V4	Avg B	1		7307	2	1631	2252
V5	**2016**	**1**	**5807**	**5757**	**2**	**1855**	**2466**
V5	Avg B	1		7562	2	1682	2328
T1	**2016**	**1**	**5265**	**5219**	**2**	**1309**	**1740**
T1	Avg B	1		5547	2	1864	2160
T2	**2016**	**1**	**4247**	**4210**	**2**	**1021**	**1357**
T2	Avg B	1		4135	2	1859	1995
T3	**2016**	**1**	**4199**	**4162**	**2**	**799**	**1062**
T3	Avg B	1		5149	2	1958	2131
T4	**2016**	**1**	**3343**	**3314**	**2**	**463**	**616**
T4	Avg B	1		4063	2	1343	1288
T5	**2016**	**1**	**4661**	**4620**	**2**	**1142**	**1518**
T5	Avg B	1		4964	2	1647	1846
T6	**2016**	**1**	**3460**	**3430**	**2**	**458**	**609**
T6	Avg B	1		3564	2	453	1070
T7	**2016**	**1**	**3772**	**3739**	**2**	**807**	**1073**
T7	Avg B	1		4329	2	1158	1595
T8	**2016**	**1**	**4808**	**4766**	**2**	**1422**	**1891**
T8	Avg B	1		5088	2	1907	2432
T9	**2016**	**1**	**3417**	**3387**	**2**	**556**	**739**
T9	Avg B	1		4375	2	1700	1638

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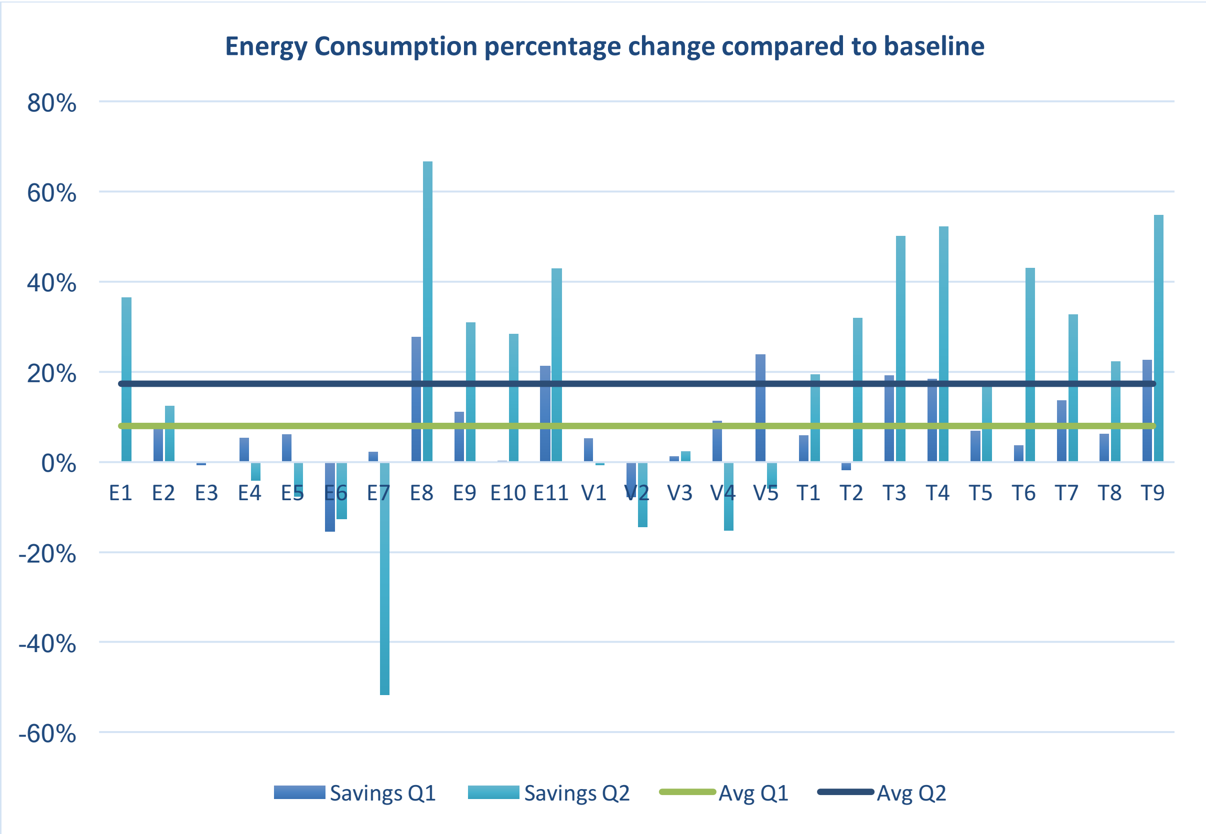

Figure 54 Percentage change in consumption compared to baseline for Max users in Fårdala

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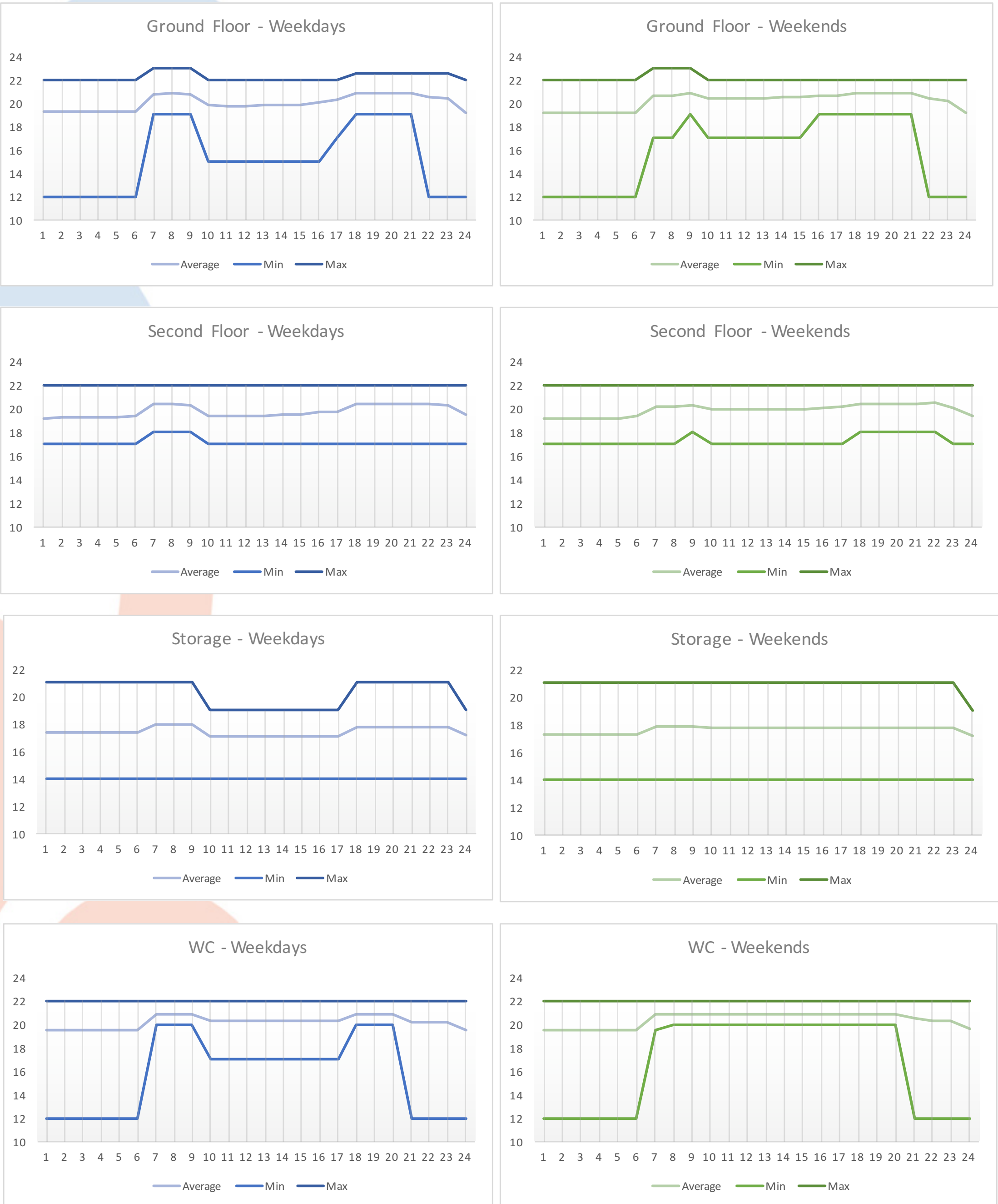

Figure 55 Average, min and max temperature profiles for indoor temperatures (Degree C) for Max users in Fårdala

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3.6.1 Max survey results

A survey was conducted in order to study the perception of users about the system. The survey was answered by 13 users. The highlights of some of the results are shown in Figure 56 - Figure 62. The survey is discussed in further detail in Deliverable 5.3. Overall, the general impression of the system was positive with over 75% respondents answering good or very good. In terms of level of difficulty of using the system 6 users found it satisfactory while 6 found it simple or very simple to use. In terms of initial expectations, 76% expressed their satisfaction with the system while about 85% of the respondents used it to lower the temperatures that aren't frequently used and for setting scheduling function for when they are not home or asleep to lower the temperature. About 60% of the users interacted with the system frequently and the main form of interaction was through the smart phone app. The results from the survey are further discussed in D5.3.

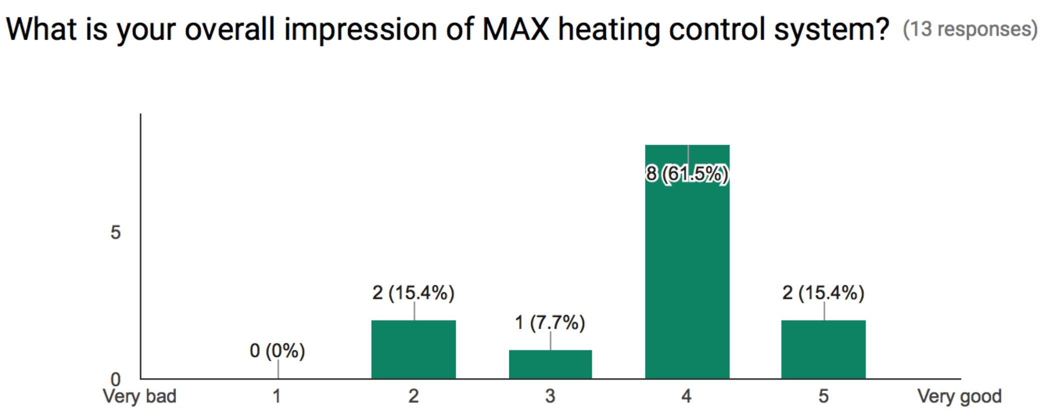

Figure 56 Overall impression of the Max users (1) very bad to (5) very good

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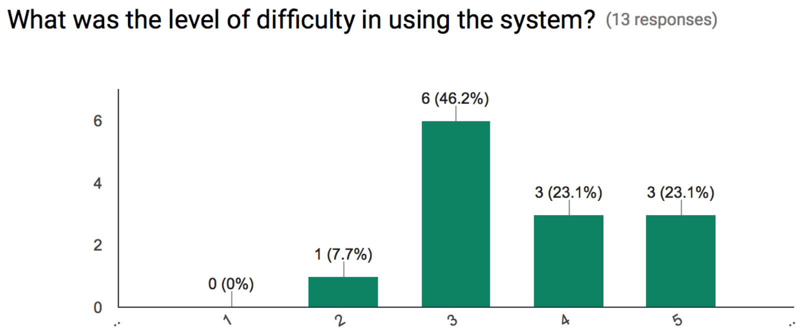

Figure 57 Level of difficulty of use from (1) very difficult to (5) very simple

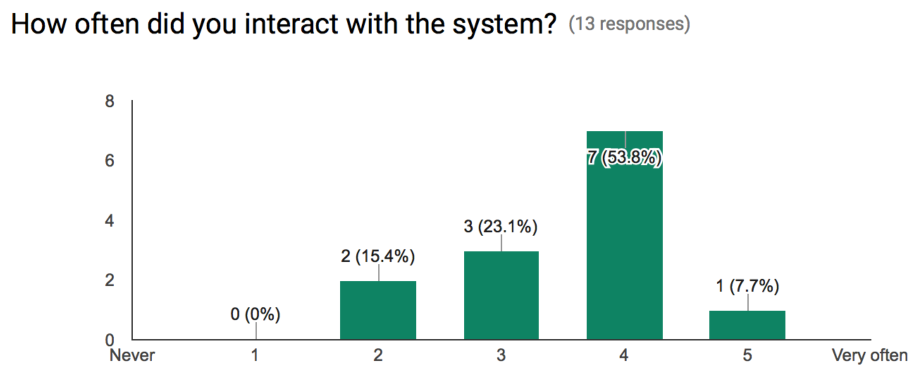

Figure 58 Frequency of interaction with the system from (1) never to (5) very often

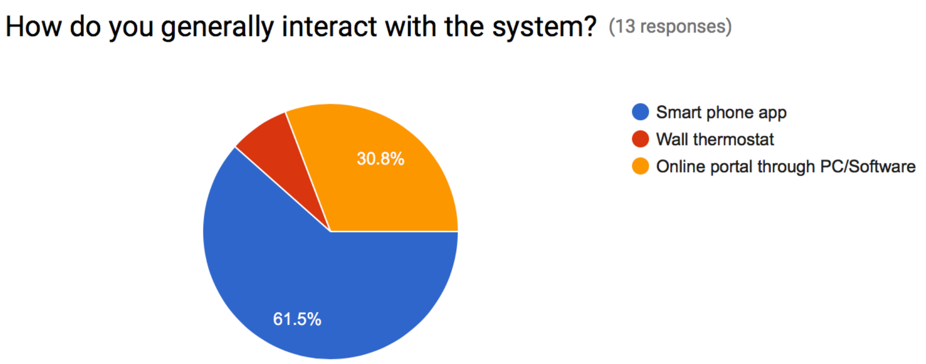

Figure 59 Mode of interaction with the system.

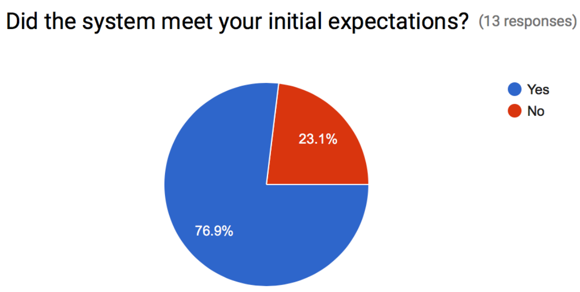

Figure 60 Satisfaction level of users.

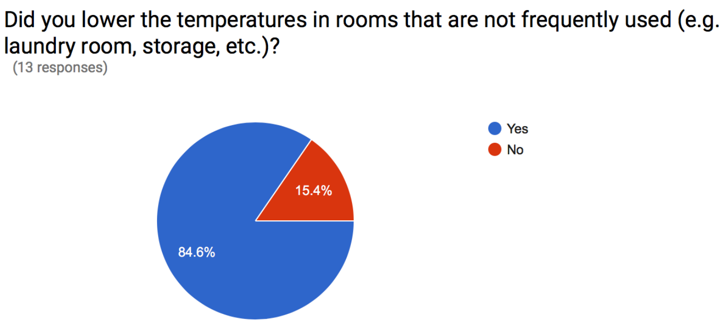

Figure 61 Percentage of users that lowered the temperature is less frequently used rooms.

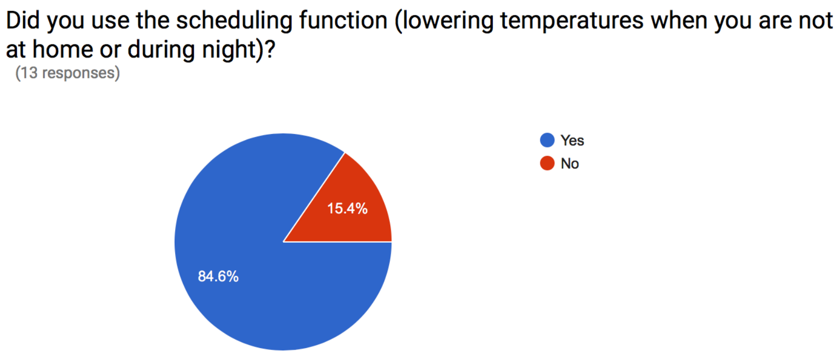

Figure 62 Percentage of users that used the scheduling function.

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4 CONCLUSION

The main objective of WP7 has been to test the effects, in terms of reduced energy use and reduced CO2 emissions, of the technology proposed within the CIVIS project, by running extensive real-life evaluation tests on the two pilot sites. The following objectives are identified:

- To measure the reduction of energy consumption and of CO2 emissions through the introduction of the CIVIS ICT platform.
- To analyse the social and economic drivers for the success (or failure) of the measures.

This section provides a summary of the findings relating to these objectives for each of the two pilot sites, followed by general conclusions and implications from the work package.

The overall impact in the Stockholm test site can be summarized as:

- The housing association aspect of the project was quite successful in achieving impact. The initiative was highly appreciated by the various stakeholders and various suggestions were made in order to improve and continue the process. As a result, a continuation project funded by the Swedish Energy Agency was launched to expand the work in this area with a goal of recruiting 100 housing associations. Further development of the platform for that aspect is ongoing and various stakeholders have been engaged in the process. It must be noted here that at the housing association level, the calculating the impact of such a project in terms of kWh reductions is challenging since the decision-making processes are usually very slow and for major actions can take several years.
- At the household level, various challenges became obvious in terms of engaging the users and changing their behaviour. The monetary savings potential in most cases was not substantial enough to engage the users in a long term shift. This was particularly obvious in Hammarby Sjöstad which has a higher average income compared to the Stockholm average. Additionally, in some cases competing apps were available to the users from the DSO with visualizations of energy use, which may have affected the uptake.
- For Smappee intervention, most of the users found the system complex and hence the

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full potential was not utilized. It did manage to engage the users initially with some users more interested in the advanced functionalities than the others.

- The Max intervention in Fårdala was successful overall. The three-month billing cycle may have affected the full utilization of potential since the users couldn't directly see the impact on their energy use. This lead to the housing association investing in an ICT platform which will be deployed by the end of the year and will enable the users to view their consumption at a higher resolution.

Summary of Italian results:

- The main findings in terms of energy impacts for the ToU signals implemented in Storo and San Lorenzo showed that statistically significant results for shifting energy use did not emerge; the small sample size surely contributed to this. However, findings did suggest that PV owners were both more engaged with the ToU signals on YouPower and also slightly more successful in following them (CEDIS).
- PV self-consumption (% of self-consumption of the PV electricity) increased for 11/21 of CEIS users comparing to 2014 and for 4/6 of CEDIS users compared to 2013.
- Overall, in Italy, the use of temperature sensors and indoor temperature visualization helped a good control of space heating demand (SH demand) in the CIVIS project (only an overall 11.4 % of hours of overheating). The data shows that in the CIVIS winter period (1 October – 30 April), on average, the thermal behaviour of CIVIS users in the control of T indoor, meets the recommended standard value of 20°C.

Conclusions and outlook:

- Interventions demonstrated the feasibility of user engagement though better information on energy usage patterns.
- Most if not all of these interventions exhibit scalability, which means they can easily be transferred to other contexts.
- In general, the most successful aspects of CIVIS interventions involved multipliers such as Housing Associations or Local Authorities

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- Significant challenges were faced in terms of data availability and timing of the interventions, which should be addressed in future trials. Ideally, there should be a time lag between interventions and monitoring, and before and after data, over a period of several years, are required.
- In addition, sample sizes and compositions should be representatively chosen in order to obtain statistically significant results; this should be borne in mind for future projects.
- Often monetary savings alone were not enough to motivate users to change their behaviour, which confirms findings on barriers, market failures and the rebound effect from the literature.
- Whilst the rollout of smart interfaces and apps was successfully achieved in the context of CIVIS, the implementation of a "social network for energy", i.e. the CIVIS vision was not completely achieved.
- This goal could be pursued in future projects in order to overcome existing barriers and appeal to other incentives than purely economic.

In terms of overall quantitative impact of social aspects on energy consumption, this has been difficult to determine in certain cases due to limited monitoring time and partial availability of historical data. In this case a comparison such as between a test group and a control group of users cannot be accurately made due to the inability to isolate the impact of interventions in an open socio-technical system. The quantitative evaluations/comparisons were therefore, where necessary, supported by various qualitative methodologies such as interviews, focus groups and surveys. One major challenge towards quantification of the results was the lack of high quality data which had to be supported by the installation of additional sensors (not originally envisaged in the project), thus leading to shorter evaluation periods. In order to fully determine the impact of social related measures on energy consumption, longer period of energy data collection as well as more detailed monitoring of energy behaviour through higher level of user engagement or additional tracking through apps/sensors of users' actions need to be carried out. This is particularly important to evaluate long term behaviour changes and the impact of rebound effects.

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