Balanced European Conservation Approach

ICT services for resource saving in social housing

DELIVERABLE

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BECA Pilot Evaluation Results

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REVISION HISTORY AND STATEMENT OF ORIGINALITY

Revision History

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0.1	Oct 13	Ina Renz	IWU	Development first draft: document structure
0.2	Nov 13 - Jan 13	Ina Renz, Ulrike Hacke Günter Lohmann	IWU IWU IWU	Development first version: introducing evaluation results including consumption, survey and combined analysis, overall results, introductory chapters
0.3	Dec 13 –Jan 14	Ina Renz	IWU	Revision of chapter 4 based on additional input from pilot sites
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2.0	Apr – May 14	Ina Renz, Ulrike Hacke	IWU IWU	Revision

Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Reviewer comments made at the final review meeting in Darmstadt

The following table lists the comments referring to this deliverable and how the consortium addressed them:

Reviewer Comment	Response from the BECA consortium

The deliverable must address the issues related to pilot site comparability and externalities (issues raised, requirements and recommendations of the 2nd review, namely draw conclusions on technology enabled energy savings, elaborate on externalities that may impact on behaviour and energy consumption)	**The comparability of pilot sites**
	• Addressed in section 2:
	  • Comparability of savings at pilot sites is given by applying control group designs according to the common methodology developed by all ICT PSP projects
	  • Comparability is given with respect to results by applying unique, standardised instruments for data collection, unique methods for savings calculations including HDD corrections
	  • When comparing pilot sites their different contexts have to be considered. This has been done in the interpretations of each site.
	• Comparisons have also been revisited in sections 3 and 5
	
	Issues related to externalities
	• Addressed in section 2:
	  • With help of the control group approach externalities such as price increases, general trends, building-types are controlled for; therefore experimental and control groups need to be identical with respect to such aspects
	  • Control group approach has been explained in more detail
	• Influence of externalities has been explained in more detail in section 3 and 5
	
	Conclusions on technology (services) and externalities that may impact on behaviour and energy consumption
	• Addressed in section 3 within additional analysis / interpretations (also see below)
	• findings are integrated in section 5 and the Executive Summary

The deliverable must include an analysis of the influence of factors related to buildings and HVAC systems on the savings achieved	**Analysis of the influence of factors related to buildings and technologies** • Section 3 includes an additional analysis / interpretations about the influence of buildings, services and technologies on heat energy savings • The extent of interpretations on the influence of building characteristics as far as possible in a project focusing on ICT technology is clarified in section 1 and 2 • HVAC SYSTEMS have not been changed during the evaluation period and are controlled for by applying the control group approach as clarified in section 2 • Those additional findings are integrated in section 5 and the Executive Summary

Contents

Executive Summary

Deliverable D7.2 describes the service evaluation of seven pilot sites participating in the BECA project. The evaluation approach includes consumption calculations using pre-post and control group designs as well as surveys and a structured interview. The majority of pilot sites has achieved or even overachieved the targets set prior to the project. Across all pilot sites the BECA project achieved average savings of 15% for heat energy, 11% for cold water, 17% for hot water consumption and 2% for electricity. Resource management services (RMS) are generally more effective than Resource Awareness Services (RUAS).

***Innovation triggered**: By using comprehensive means including EC tools such as eeMeasure and the Common Approach for CIP projects, the BECA project could identify the immense potentials of RMS enabled services particularly for heating and water.*

The BECA project equipped 2,300 dwellings in social housing contexts with metering equipment for the monitoring of their energy and resource consumption. Among those dwellings, 1,524 dwellings have been part of the experimental group. The remaining dwellings were established as control group with metering equipment installed, but without access to the services during the project. This enabled 3,353 tenants (calculated with an average household size of 2.2 persons) to benefit from the services.

The **evaluation approach** in BECA is based on the 'Common Methodology' to be used across all ICT-PSP projects (the approach was mostly finalised by the BECA consortium). Consumption calculations were predominantly performed and verified with the eeMeasure tool based on that 'Common Approach'. The best design available for the BECA project is the application of a pre-post design with control group. The advantages lie in elimination of programme-external influences including, among others, building / tenant characteristics and exogenous trends and learning effects. Pre-post design considers changes related to dependent variables over time by comparing baseline period with reporting period. At the same time initial differences between experimental group and control group (which cannot be due to the services) and differences between both groups during the reporting period can be identified. This design helps to identify the net effect of the services and ensures that energy savings and changes in behaviour or awareness are neither caused by external influences or are due to random effects. With help of this design, program-external factor were controlled and robust results about savings could be achieved. However, the influence of single externalities cannot be separated or quantified statistically (and this was not planned and is hardly possible in a pilot study).

Overall results revealed a great success that can be enlarged by extending the operation period of the services, giving the tenants more time to adapt their behaviour. For the resources covered by the majority of sites savings of 15% for heat energy, 11% for cold water and 17% for hot water have been achieved. Only for electricity the target was not met (2%). However, it has to be taken into account that the most effective way to achieve meaningful electricity savings is to replace old electric appliances by new and less energy consuming ones. The tenants of social housing often do not have the means for doing so and assess it as not useful to replace appliances when the old ones still work well. As all pilot sites will continue the provision of their services they can base their future campaigns, energy coaching and further activities on the current success of the project.

The combined analyses of consumption data and survey data has shown various relations between ecological awareness as well as ecological behaviour and the achievement of savings. Higher savings where achieved at most pilot sites when the energy saving norm increased together with interest in saving energy at home and in possibilities of saving energy at home. The data allowed for analysing the relation between the retrospective view of the tenants and the achieved savings at one pilot site: Tenants who stated to know more about their energy consumption due to the tenant portal or stated that they now keep an eye on their energy consumption performed better than tenants who do not think so. Furthermore there is evidence

that improved behaviour and achieving savings are related to the frequency of portal logins. At most pilot sites medium and or heavy portal users performed better than weak users.

There are **differences in the savings across pilot sites** illustrating the importance of individual contexts, conditions and dispositions in the national societies for the achievement of savings. With respect to heat energy consumption the pilot sites at Darmstadt and Örebro achieved the highest savings of 20% and 19% which is mainly due to using RMS which automatically optimises the supply water temperature in the case of Darmstadt and sets the indoor temperature at a maximum of 21 degrees Celsius at Örebro. Related to cold water consumption Belgrade and Örebro achieved the highest savings of 16% and 37%. These high savings in Örebro are at least partly due to a specific condition introducing a new billing system with now water expenditure calculation on the basis of the actual consumption of the tenant households. This made tenants very responsive to the RUAS services. At Belgrade the experimental group tenants showed a remarkable increase in their subjective energy saving norm, therefore felt responsible to save energy and improved their behaviour related to water consumption. The highest reduction of hot water achieved again Örebro due to the above mentioned reasons (35%) and Torino (31%) where the mainly elderly tenants with low pensions have been highly motivated to save money. Regarding electricity consumption that was part of the project at three pilot sites, Ruse achieved the highest savings with 6% by targeting high-consumers with additional coaching.

While drawing **conclusions** largely varying conditions need to be considered as the local context might have varying influence across pilots. Nonetheless, results suggest that RMS generally is more effective than RUAS. In that context one important advantage of RMS is that its effects inure to the benefit of whole buildings. As a consequence the optimal service setup seems to be the provision of combined RMS and RUAS which can bring out the potentials lying in optimising operations of buildings together with optimised user behaviour. This was also shown by a building-specific analysis on heat energy consumption. Furthermore RMS technologies that automatically regulate energy related features (such as Techems' adapterm or setting a limit room temperature) seem to have a bigger impact than systems that serve as monitoring instruments for detecting malfunctions.

Within RUAS, using paper reports or offering a service hotline and coaching to tenants in addition to the web-based services are important. This is demonstrated by the fact that tenants of the experimental group who did not became active portal users also achieved meaningful savings (e.g. in Belgrade or Havirov).

RUAS can be considered as useful instruments for the achievement of durable reduction of energy. At all pilot sites tenants show an increased ecological awareness. The same applies to the ecological behaviour of tenants becoming apparent also for resources not addressed with the BECA services. Such spill-over effects indicate that when tenants started watching out for their ecological behaviour, they do so in all domains of energy use.

Key strategies, used by social housing tenants, have been identified: The heat energy consumption was mainly influenced by turning off the heating when opening windows and turning down the heating when leaving the home for a longer time. Warm water consumption has been reduced by using cold water for washing hands and taking a shower instead of a bath. With respect to electricity consumption, to mind the energy consumption when purchasing new appliances showed the strongest influence on electricity consumption among the everyday practice related to electricity consumption.

Innovative features considered successful include the 'character' BECO (Manresa) increasing attention to the project and forecasting of costs based on the energy consumption of the households (Örebro).

Overall, ICT services are strongly depending on the initial situations at pilot sites. This is true for the achievement of savings as well as for the improvement of behaviour or the increase of ecological awareness. If, prior to start of a service, energy consumption is already low or the level

of behaviour and awareness is high, the potential for savings and improvements is low. Once the conditions are in favour resource efficiency RUAS becomes a tool to detect wastage.

Although some more program-external factors influence the impact of the services (e.g. building-type, billing system), it was shown that savings could be achieved across all pilot sites independent of those factors. That's why ICT services for energy savings and efficiency are useful for various kinds of contexts.

Achievements have to be seen against the background of a short operation phase for tenants to get aware and to break with their current behaviour in everyday life. In addition, tenants addressed have to overcome various barriers to achieve energy savings: low IT-literacy and limited access to internet are excluding factors that normally cannot be solved by housing companies. Hence, absolute savings are likely to increase once all tenants can be reached integrating BECA services in an overall strategy for IT-skills.

1 Introduction

Deliverable D7.2 reports on the BECA pilot evaluation results based on the different data collection phases (Tasks T7.1 – T7.4). The focus lies in the provision of an impact analysis of the ICT solutions that have been developed and operated by the participating pilot sites. These solutions are focussing on Resources Management Services (RMS) and Resources User Awareness Services (RUAS).

Resource User Awareness Services (RUAS) operated in BECA generally consist in ICT-based provision of consumption feedback in form of tenant web portals. In some cases paper-based feedback is additionally provided. The feedback shall enable users to get a better knowledge about their energy consumption at home and to raise their ecological awareness. The ICT solutions allow well illustrated and understandable feedback of short-time consumption periods (e.g. per month) with historical (comparison with previous periods) or comparative feedback (comparison with similar households). In addition to that, energy saving tips or alert systems is included. By using the portals, tenants can learn to act in a more energy conscious way.

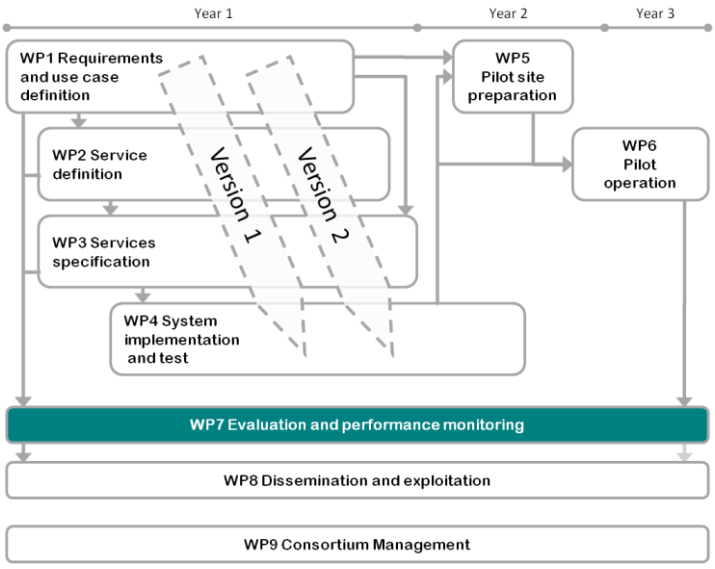
Resource Management Services (RMS) installed and operated in the BECA pilot sites shall help to optimise the modus of operation, to monitor the energy flows and therefore to be able to detect and solve malfunctions rapidly.

Corresponding to objective 1.1 of the ICT PSP Work Programme 2010 (ICT for energy efficiency in social housing), these ICT components shall be able to contribute under real conditions to reduce waste of energy and water. The target is to achieve more than 15% of savings in peak demand and annual consumption of energy. The target group consists of tenants who live in situations characterised by low incomes, educational level and internet access rate. Some tenants have little or no ecological awareness. Hence, the inclusion of the tenants' perspective through evaluation is of major importance while developing a service.

The project was designed with a strong focus on ecological behaviour and awareness of tenants. As behavioural aspects are not primarily depending on the quality or type of building, the influence of such aspects on the achievement of savings was not a target of the project and therefore not investigated in detail. However, the services have been tested in different kinds of buildings and settings.

As depicted below, work package 7 (WP7) is a horizontal action active throughout the project.

Figure 1.1: BECA Project structure



The structure of the document is as follows:

- Chapter 2 introduces the evaluation approach and methodology used.
- Chapter 3 summarise the main overall results of the impact assessment analyses.
- Chapter 4 reports on the detailed pilot site-specific results.
- Chapter 5 contains the conclusions of the project with respect to the provided services and their impacts and perspectives for the future.

2 General Evaluation Approach in BECA

The evaluation approach used in BECA was described in detail in Deliverable D7.1 “Evaluation Plans for BECA” which is a confidential document and not available for the public. That’s why this chapter takes up the main aspects of the approach related to the project objectives in order to give background information. The structure of representing the findings is also clarified. This allows a better understanding of the impact analysis for the reader.

The BECA project aims at the reduction of energy and water consumption that shall be achieved by the installation of RMS and RUAS. Additionally, RUAS shall result in a change of ecological behaviour and awareness of the service users. In order to motivate tenants for usage, the services should be attractive for the end-users, and a sufficient high number of active users should be achieved. These targets were evaluated by measuring the following dependent variables: Amount of consumption for the relevant resources, self-reported consumption behaviour, ecological awareness of tenants and tenant satisfaction with the portal as well as the use frequency of the RUAS tenant portal.

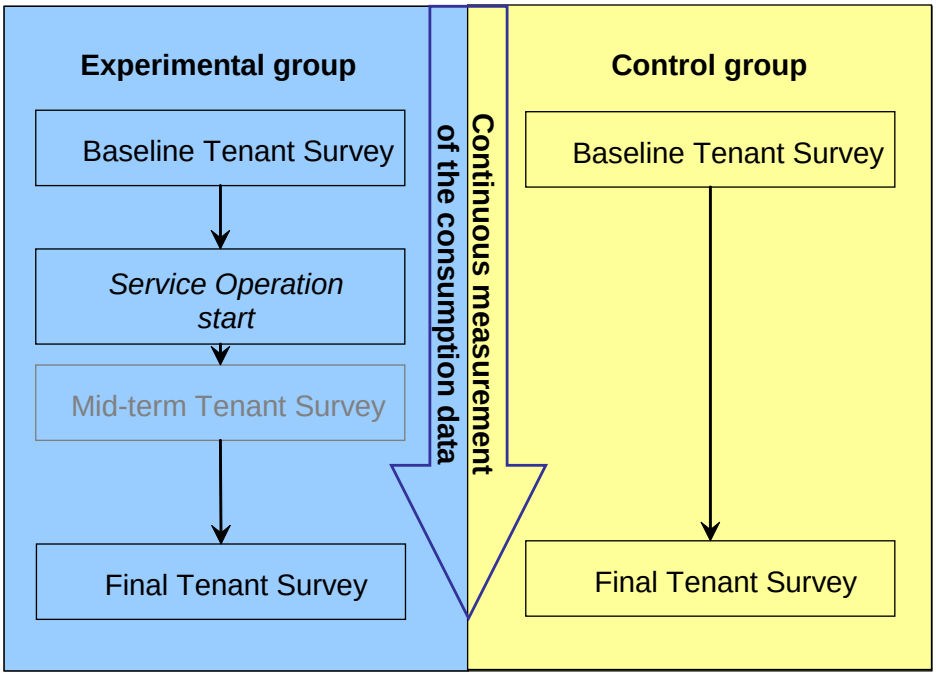
The main objective of the evaluation work was to establish an impact assessment of the operated services taking into account that effects of programme-external influences (such as characteristics of buildings or tenants as well as general factors as structural trends such as price increases or learning effects) are best possible eliminated. Therefore it was recommended to apply a pre-post design with control group.

This design allows considering changes related to these dependent variables over time by comparing baseline period with reporting period. At the same time initial differences between experimental group and control group (which cannot be due to the services) and differences between both groups during the reporting period can be identified. This design helps to identify the net effect of the services and to ensure that energy savings and changes in behaviour or awareness are neither caused by external influences nor are due to random effects. This means that with the help of the control groups that are part of the methodological evaluation design in BECA, it is possible to control for externalities that may have an impact on behaviour and energy consumption when savings from experimental groups are compared with savings from control groups. Consequently, it is necessary that control groups and experimental groups do not differ systematically with respect to those externalities. This was considered when chosing the control groups (e.g. with respect to building types / energetic quality of buildings incl. the used HVAC or characteristics of the tenants) and with respect to structural trends such as changes in the socio-political attentiveness towards energy saving issues, price increases, general trends in cultural societies or learning effects is given due to the fact that control groups and experimental groups are situated in the same settings and are prone to the same societal conditions.

When constructing control groups, it is important to ensure that the control group matches the characteristics of the experimental group as much as possible. Preferably identical building types with the same energetic quality, HVAC and relation of public and private areas are selected to comply with these criteria. In addition to that, the social structure of the tenants should be comparable. Otherwise, differences between both groups should be known (e.g. via tenant survey) to consider these in the analysis and interpretation. As a consequence, the only difference between both experimental and control group should be the availability resp. the absence of the service. In the case of absent control groups or as an additional level of analysis, service user/non-user comparisons within the experimental group can provide further insights and evidence. Users are all tenants who logged in to the RUAS tenant portals at least once. Those who had the possibility for service use, but didn’t log in were counted as non-users.

The application of this design requires the availability of data operationalising the dependent variables related to both baseline and reporting period. In addition to that, data about programme-external influences within both periods can help to eliminate undesirable effects statistically or help to interprete the results against this knowledge (e.g. differences in socio-economic structure of tenants).

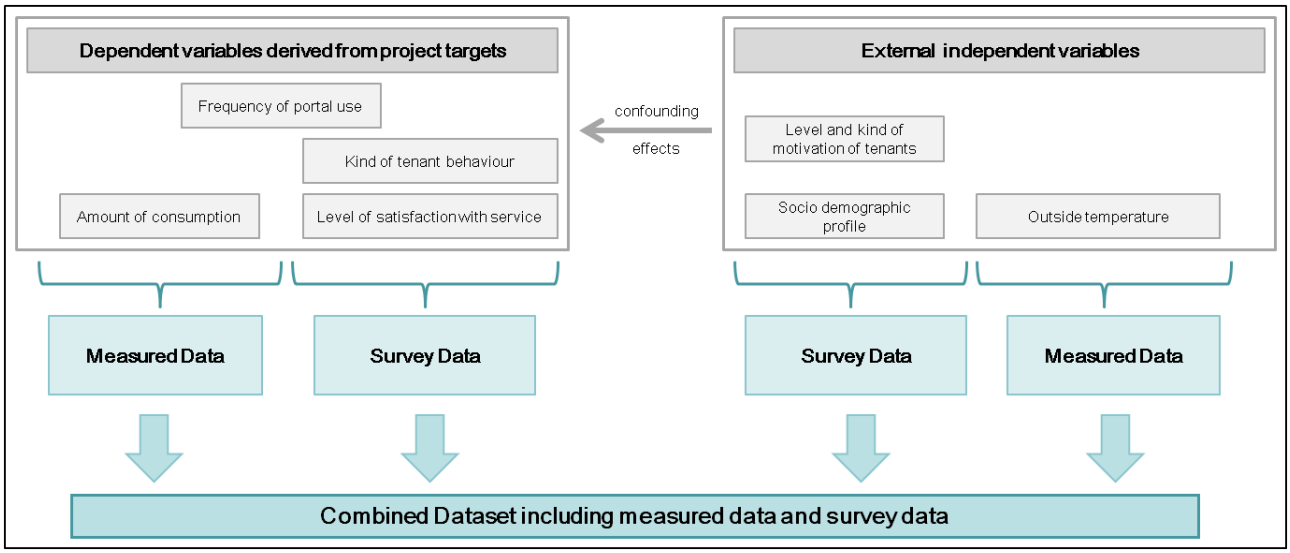
Figure 2.1: Suggested evaluation design



As figure 2.1 shows, two kinds of data are needed for the realisation of the BECA evaluation approach: the monitoring of energy/resource consumption measured continuously within both periods and tenant survey data gathering information about subjective behaviour and awareness as well as context information that is collected in at least two panel stages before and after the start of the services. These data are needed for both control group and experimental group. A mid-term survey is not of major importance for the impact assessment, but can provide further information about possibilities to improve the tenant portal.

As there is a strong focus on the inclusion of the tenants' perspective in BECA, there were generated combined analysis datasets by matching the survey data of two panel stages and the consumption data covering the whole time period. That matching process was realised by using unique dwelling-IDs. By doing so, data protection is ensured as best as possible.

Figure 2.2: General Measurement Approach



In deliverable D7.1 the methods for measuring the success of the pilot sites and the whole project have been developed. This approach based on the common methodology that has been worked out in the course of the ICT PSP Work Programme on ICT for energy efficiency in social housing and has been enlarged according to the needs of BECA[1]. That common deliverable systematises and deepens the methodologies known in Europe for the measurement of energy savings and emission reduction in the residential sector. It serves as a guide for further projects with similar objects of investigation. The special task of the BECA project (following after the projects 3e-Houses and eSESH) in that context was to establish the control group approach as an important instrument which allows for further findings which are probably more significant than “simple” pre-post comparisons.

The project and evaluation design of BECA has some implications for the comparability of the results from different pilot sites.

The focus of WP 7 is on the impact assessment of the single services at the pilot sites with their own requirements and contexts and not on the comparison of pilot sites. That’s why comparability must be given within the pilot sites with respect to the selection of experimental and control groups (as described above). In addition to that the savings of the pilot sites can be interpreted against their specific contexts and characteristics. That‘s why the comparability of pilot sites is ensured with respect to the methodology for savings calculations also including temperature adjustments for heat energy and the application of uniform and standardised instruments for the collection of consumption and survey data (see sections below).

As the requirement of the control group approach is not to separate program-external influences statistically (but only to exclude them) and due to the purpose of the project (see also section 1), it is not possible to quantify program-external influences across pilot sites such as the influence of building-types on the savings achieved. For this purpose, a special research design is needed where building-types would be systematically varied whereas services and other factors should stay more or less constant. This is hardly achievable in pilot studies, where a huge heterogeneity is given.

[1] http://beca-project.eu/fileadmin/BECA/documents/beca_residential_methodology.pdf

2.1 Methodology of consumption measurement analyses

2.1.1 General approach

The general approach in BECA is originally based on the International Performance Measurement and Verification Protocol (IPMVP) and further developments done by several projects of the ICT PSP Work Programme that are reported in a common methodology. These documents suggest pre-post comparisons, in the best of cases by additional use of a control group approach.

Table 2.1.1: Overview on application of evaluation designs

Site	Energy type and unit	Analysed baseline period (from	to)	Control group available	Evaluation design
Belgrade	Heating (kWh)	Nov 2011	Oct 2012	Yes	Pre-Post with control group (building-wise data only)
	Cold Water (m^3)	Nov 2011	Oct 2012	Yes	Pre-Post with control group (building-wise)
	Electricity (kWh)	Nov 2011	Oct 2012	Yes	Pre-Post with control group
Darmstadt	Heating (kWh)[1]	Dec 2011	Feb 2012	Yes	Pre-Post with control group
	Cold Water (m^3)	Nov 2011	Oct 2012	Yes	Pre-Post with control group
	Hot Water (m^3)	Nov 2011	Oct 2012	Yes	Pre-Post with control group
Havirov	Heating (kWh)	Dec 2011	Oct 2012	No	Pre-Post with user/non-user comparison
	Cold Water (m^3)	Dec 2011	Oct 2012	No	Pre-Post with user/non-user comparison
	Hot Water (m^3)	Dec 2011	Oct 2012	No	Pre-Post with user/non-user comparison
Manresa[2]	Heating (kWh)	Nov 2011	Oct 2012	No	Pre-Post (exp. Group only)
		Analysis related to reporting period: Nov 2012-Apr 2013		Yes	Cross-sectional analysis with control group
	Cold Water (m^3)[3]	Mar 2012	Oct 2012	Yes	Pre-Post with control group
	Electricity (kWh)[3]	Mar 2012	Oct 2012	Yes	Pre-Post with control group
	Electricity Peak Demand (kWh)	15 Oct 2011	28 Oct 2011	No	Pre-Post
Örebro	Heating (kWh)	Jan 2012	Oct 2012	No	Pre-Post (RMS, district-wise)
	Cold Water (m^3)	Jan 2012	Oct 2012	No[4]	Pre-Post with user/non-user comparison
	Hot Water (m^3)	Jan 2012	Oct 2012	No[4]	Pre-Post with user/non-user comparison
Ruse	Cold Water (m^3)	Dec 2011	Oct 2012	Yes	Pre-Post with control group
	Electricity (kWh)	Dec 2011	Oct 2012	Yes	Pre-Post with control group
Torino	Heating (kWh)	Nov 2011	Oct 2012	Partly (RUAS)	Pre-Post with control group
	Cold Water (m^3)	Nov 2011	Oct 2012	Partly (RUAS)	Pre-Post with control group
	Hot Water (m^3)	Nov 2011	Oct 2012	Partly (RUAS)	Pre-Post with control group

[1] compared to original plans shortened comparison periods due to divergent operation starts (see detailed chapter)
[2] The originally planned feedback on hot water could not be realised due to technical problems.
[3] shortened period due to the available baseline data of the control group
[4] As explained in the detailed chapter, the control group approach could not be realised as planned.

As the above overview table shows, all pilot sites realised consumption measurements which allow pre-post comparisons. In each case, the presented baseline period corresponds with an equal

duration of the reporting period. In five of the seven pilot sites both comparison periods cover 12 month in each case (at least related to single resource types). In the remaining cases the periods cover less than 12 month due to guaranteeing the comparability of both periods. The reasons for that are explained in detail in the pilot site-specific chapters.

In five of the seven sites furthermore a control group approach could be realised. The construction of control groups requires comparable dwellings/buildings without service operation (as described above) which were not available at the remaining two sites (e.g. due to new constructions).

With a few exceptions in Belgrade and Örebro usually dwelling-wise data were available. Depending on the energy type, the measured consumption data have been analysed related to the dwelling size (m^2) and/or the number of persons living in the dwelling.

In addition to that temperature adjustments have been carried out when comparing the heat energy consumption within different heating periods in order to subtract out climatic effects. In doing so, different methods are known. As a commonly-used practice, a heating degree day calculation model (HDD) has been used. The HDD have been calculated based on provided temperature data by weather services of the several countries. A degree-day-correction generally allows comparisons of consumption data related to several time-periods (e.g. years, heating periods) – regardless of the diversity of climatic conditions of these measurement periods, of the location of the settlement/building, etc. By using those correction models it is possible to measure differences in consumption figures on a percentage basis.

2.1.2 Data collection and data cleansing procedures

The data collection has been realised by means of a standardised MS Excel template. This consumption matrix was filled in by the pilot site managers and provides the following information by using a unique dwelling/tenant ID for data management:

- General information about dwelling characteristics such as size of dwelling, number of persons living in the dwelling, specific technical equipment (e.g. availability of a mechanical ventilation system, availability of an automatic night setback) and evaluation information (kind of service, evaluation group status)
- Information about a change of tenancy including move-out and move-in dates, vacancy of dwellings
- Measured consumption data for each relevant resource on a usually monthly basis
- Measured portal logins

To ensure the conclusion that energy savings are actually an impact of the provided services and not caused by other unwanted factors, it is important to base the savings calculation on identical characteristics of buildings and tenants within both baseline period and reporting period. Due to the fact that energy consumption may strongly vary between different households, it is important to exclude all dwellings with a change of tenancy within the project duration from the analyses. Another necessity was the exclusion of unoccupied dwellings and dwellings with too late move-in dates. The same applies for dwellings with inconsistencies in the measurement (e.g. negative values) or missing consumption data due to malfunctions of the metering devices, a long absence of tenants living in or – sometimes mainly in the case of electricity – due to cut-offs as a consequence of outstanding debts.

However, the following table shows that the data of at least 800 up to 1.900 dwellings – depending on the resource – could be analysed. That equates up to 82% of the basic population. In addition to that, the table gives a short overview of the reasons for data exclusion which can be found in more detail in the site-specific chapters below.

Table 2.1.2: Overview on number of dwellings in evaluation groups

Site	Number of buildings involved	Total number of dwellings involved*	Number of dwellings included in consumption data analyses	Data cleansing impacts (number and percentage of excluded dwellings)
Belgrade	3	184	Heating: 184 (exp. 92+contr. 92) Electricity: 148 (79+69) Cold water: 184 (92+92)	Electricity: 36 dwellings (20%) due to missing data of several months
Darmstadt	45	675	Heating: 349 (RUAS: exp. 90+contr. 259; RMS: 210+139) Hot water: 557 (RUAS: exp. 188+ contr. 369) Cold water: 557 (RUAS: exp. 189+ contr. 368)	Change of tenancy (applicable for all resources): 116 (17%) Further exclusion: Heating: 210 (31%, due to mix of cumulated and monthly data) Hot water: 2 (0.3%, missing data) Cold water: 2 (0.3%, missing data)
Havirov	2	72 (heating) 36 (water)	Heating: 63 Hot water: 30 Cold water: 28	Heating: 9 (12%; change of tenancy) Hot water: 6 (17%; change of tenancy: 5, missing values: 1) Cold water: 8 (22%; change of tenancy: 5, missing values: 3)
Manresa	5	122 (+8 unoccupied)	Heating: 66 (exp. 23+contr. 43) Cold water: 68 (27+41) Electricity: 69 (28+41)	Change of tenancy (applicable for all resources): 42 (34%); Exclusion due to missing data: Heating: 14 (11%) Cold water: 12 (10%) Electricity: 11 (9%)
Örebro	10 (districts)	435	Heating: all 10 buildings Hot water: 67 Cold water: 67	Hot and cold water: 368 (85%; change of tenancy: 147; missing values due to a massive failure of the metering equipment: 221)
Ruse	2	115	Electricity: 73 (exp. 32+contr. 41) Cold water: 61 (26+35)	Exclusion due to missing data: Electricity: 42 (36%) Cold water: 54 (47%)
Torino	33	Heating: 697 DHW: 309 Cold water: 595	Heating: 497 (exp. 243+contr. 254) Hot water: 82 (39+43) Cold water: 414 (219+195)	Exclusion due to change of tenancy (in total: n=40) resp. due to missing data: Heating: 200 (27%) Hot water: 227 (73%) Cold water: 181 (30%)
Total	**100**	**1,876 – 2,300**	**801 – 1,878**	

* Basic population with experimental group and control group included

2.1.3 Calculation and presentation of savings as impact of the BECA services

As above described, the calculation of savings was carried out by pre-post comparisons with additional control group comparisons if applicable. Regardless of the realised evaluation design, dwelling sizes and household sizes have been taken into account and temperature adjustments have been done where appropriate.

For analysing the energy consumption data in BECA the common calculation tool “eeMeasure” (developed in the context of the project Smart Spaces) should have been used in order to get directly comparable results of all projects of the ICT PSP Work Programme.[2] The calculation approach of eeMeasure bases on regression-analytical and imputation algorithms which meet the criteria of the IPMVP (International Performance Measurement and Verification Protocol), but which is not the only commonly used option of calculating savings. The calculation of savings usually can be realised with at least two approaches:

1. In the first approach – also used in eeMeasure – the savings calculation is related to the total energy/resource consumption measured in the baseline period as well as in the reporting period (if applicable with further adjustments, e.g. HDD-correction in the case of heat energy). That means that first all individual household consumption figures for both comparison periods have been summed in order to calculate secondly the percentage change based on the difference of both sums by using regression-analytical and imputation algorithms if applicable.
   That approach is appropriate for the calculation of the global change in pre-post comparisons (total savings or increased consumption).

2. A different approach makes use of averaged individual savings resp. increased consumption figures of each household. That means that first the percentage savings (resp. increased consumption) of each household were calculated in order to secondly average over these individual savings (resp. increased consumption).
   That approach is appropriate for analysing the effectiveness of an intervention with stronger focus on the individual household level. Even that individual impact is of special BECA interest, so that the detailed group differentiations (incl. significance tests of group differences) and cross-sectional analyses will use that second approach. That also applies to the combined analysis of survey data and consumption data (see below).

Both approaches must not, but can lead to divergent results. That is especially true for the case of households with comparably extreme low or high consumption figures resp. extreme high increases or savings. A simple exclusion of those cases would not be constructive because those consumption characteristics are not necessarily abnormal. Nevertheless, those households carry different weight when using both calculation approaches. That’s why in the consumption analysis chapters always both calculation models were taken into account by additional illustration of the described extreme values. In general the results of the consumption data analysis are presented as follows:

- Global values of savings in absolute terms (kWh or m^3) and on a percentage basis related to all relevant resources resulting from the pre-post comparisons of the experimental group (carried out with eeMeasure) – also as basis for
  - Information on carbon dioxide reduction in kg CO_2
  - Information on cost savings in €
- Percentage change related to all relevant consumptions in comparison of experimental group and control group and/or RUAS users and non-users (where applicable)
- Average absolute consumption figures per dwelling (related to the dwellings size or the household size, if applicable) in all relevant comparison groups before and after service operation
- Baseline consumption values per dwelling and achieved savings/increased consumption in order to illustrate possibly realistic, but extreme values

[2] The results can be uploaded on the website: http://eemeasure.smartspaces.eu/eemeasure/generalUser/

- Absolute number and percentage of dwellings with savings incl. the average savings of these dwellings related to all relevant comparison groups (the same applies to consumption increase)

Where appropriate, savings per dwelling have been also analysed in relation to the activity of portal users measured by the portal logins. Therefore the use frequency has been categorised in weak, medium or heavy users.

2.2 Methodology of tenant survey analysis

2.2.1 General approach

As drafted in the introductory part of chapter 2 and described in more detail in the confidential D7.1, information gathered in the survey allows for identifying changes in ecological awareness and behaviour of tenants that are due to the RUAS services. Furthermore, information about conditions to achieve a high number of end-users was collected (e.g. satisfaction with the portal).

Therefore at all pilot sites a three-stage panel design was conducted. The results of the quantitative baseline and final survey conducted in experimental and control groups will be the basis for the impact analysis. The qualitative mid-term survey was conducted with different target groups and helped to show whether the portal should be improved during the project duration (formative aspect of evaluation).

The baseline and final survey followed a standardised approach. The survey questions related to ecological behaviour and awareness, motivation of tenants, satisfaction of active users, socio-demographic characteristics and context information have been developed by the WP leader. The pilot sites were asked to add further questions about their specific interests and to adapt questions to their requirements (e.g. questions about tenant portal in final survey). All questions have been translated and programmed with help of a computer tool. Ecological behaviour and awareness are the main interesting topics as they represent dependent variables. The motivation and satisfaction of tenants are also crucial for the success of the RUAS services. Information of both surveys is also used for a combined analysis of measured consumption data and tenant's self-reports (see section 2.3).

To motivate the tenants to participate in a survey is a challenging task especially in social housing. Therefore the pilot sites applied several strategies and tried to contact the tenants a number of times via different channels. In addition to that, several sampling methods have been used (e.g. postal + face-to-face interviews). The data has been gathered by the pilot sites with help of the software tool. As a result, standardised data was available for all pilot sites.

The following table gives an overview on the achieved response rates at baseline and final stage and the strategies to reach a high number of tenants.[3]

Table 2.2.1: Overview of tenant survey sample sizes

Site	Evaluation Group	Baseline Survey			Final Survey		
		Number of evaluable interviews	Res-ponse Rate	Strategy	Number of evaluable interviews	Res-ponse Rate	Strategy
Belgrade	experimental	33	36%	1. Personal visits 2. Conducted at meeting (Tower A), personal visits by	29	32%	1. information via president of tenants assembly, information letter or officials from
	control	34	37%		29	32%	

[3] The number of interviews of tenants participated in the baseline and the final survey is reported in the pilot site specific chapter (section Data basis and profile of respondents at baseline and final survey).

Site	Evaluation Group	Baseline Survey			Final Survey		
		Number of evaluable interviews	Res-ponse Rate	Strategy	Number of evaluable interviews	Res-ponse Rate	Strategy
				officials (Beoelek)			Beoelek 2. personal visits
Darmstadt	experimental	30	13%	1. Information letter 2. Personal visits by multilingual social workers up to 3 times	10	5%	1. Information via Email / telephone (exp. group), postal letters 2. Personal visits
	control	120	26%		37	8%	
Havirov	experimental	45	63%	1. Invitation letter and leaflet 2. Personal visits up to 2-3 times 3. Contact via telephone (date agreement)	36	50%	1. Postal Survey was sent 2. Postal reminder was sent
	control	n/a	n/a	n/a	n/a	n/a	n/a
Manresa	experimental	34	81%	1. Poster announcing survey and date/hours for realisation 2. Personal visits up to 3 times at different times of day with leaflet to call back in case of absence of the tenant 4. Phone contact of tenants with high likelihood of participation due to their profile	35	80%	1.information letter five days in advance with scheduled dates and invitation to call if another date is more convenient 2. Personal visits at two days and different times of day with leaflet to call back in case of absence of the tenant 3. Contact via telephone (date agreement)
	control	52	72%		57	75%	
Örebro	experimental	125	53%	1. Sending survey via mail 2. Contact via phone and personal visits 3.Conducting during meetings	57	25%	1. Paper survey was sent 2. Non-reached tenants are contacted by phone
	control	88	50%		52	29%	
Ruse	experimental	32	71%	1. Conducting during meeting 2. Sending survey via mail	24	53%	1. Paper survey was sent 2. Non-reached tenants are personally contacted
	control	65	87%		62	83%	
Torino	experimental	94	25%	1. Personal visits 2. Contact via phone 3. Conducting during meetings/trainings	82	22%	1. Personal visits 2. Contact via phone 3. some interviews realised at meeting
	control	62	20%		75	23%	
Total	experimental	393	36%		273	25%	

Site	Evaluation Group	Baseline Survey			Final Survey		
		Number of evaluable interviews	Res-ponse Rate	Strategy	Number of evaluable interviews	Res-ponse Rate	Strategy
	control	421	35%		312	26%	

It is obvious that all pilot sites undertook enormous efforts to motivate the tenants for participation. However, the response rates are quite different at the pilot sites. Those differences can be partly caused by cultural differences in the pilot nations. In addition to that, low response rates could be partly due to the difficult social background of tenants (e.g. Darmstadt).

However, related to the baseline stage 393 interviews have been completed in the experimental group and 421 in the control group representing satisfactory response rates of 36% resp. 35%. The response rates of the final survey are somewhat lower, but they still show good results (273 interviews in the experimental group and 312 interviews in the control group).

The mid-term survey served as formative part of the evaluation. It was conducted as qualitative interviews using some guiding questions. The approaches were developed by the pilot sites. The surveys were not only addressed to the tenants, but also to staff members at some pilot sites. By doing so, it was possible to assess if the RMS systems or portal solutions worked without problems, if they are useful for the target groups or if they still needed to be improved.

The following table shows the target groups as well as the number of interviews that have been conducted at the pilot sites. All pilot sites used a guideline for interview realisation. The target was to get detailed information from the respondents telling their experiences with the BECA solutions. Therefore the focus was not primarily on getting very high numbers of respondents (as it was targeted in the quantitative surveys), but on receiving profound information. The results have been summarised by the pilot sites and are shortly reported in the pilot-specific sections below.

Table 2.2.2: Overview on pilot specific approaches for mid-term surveys

Site	Target Group	Number of interviews	Date of survey realisation
Belgrade	Tenants	19	April 2013
Darmstadt	Tenants	7	Aug.-Oct. 2013
Havirov	Tenants	10	April 2013
Manresa	Staff Tenants	4 7	March-April 2013
Örebro	Staff Tenants	1 2	April 2013
Ruse	Tenants	12	April 2013
Torino	Staff	2	May 2013

2.2.2 Methods of survey analysis and presentation

The results of the mid-term survey give an overview whether the implementation of the services started successfully or further improvement is needed. The results are presented in short reports summarising the statements of the respondents.

The survey analysis focussed in depth on the results of the baseline and final surveys as they are needed for the impact evaluation of the BECA services.

The data of baseline and final surveys have been collected from each pilot site by using the software tool programmed and provided by the pilot site leader. All pilot sites used the same questions (but adapted to their requirements if necessary). In addition to that, some pilot site asked further site-specific questions.

For analysing the survey, the data were imported in statistical software (SPSS). The analyses are based on the appropriate evaluation designs. So in most cases pre-post designs with control group were conducted. In addition to that, some retrospective questions have been asked in the final surveys providing additional information about the impact of the RUAS services.

Before presenting the results of the impact assessment, the response rates of the surveys and the profile of the respondents are described taking into account social characteristics and context information in order to display the data basis of the analysis. The RUAS use is also reported as background information of the samples. It has to be pointed out that the frequency of portal use and the identification of active users that is assessed with help of the survey data not necessarily equals the results assessed on the basis of the login-data reported by the pilot site leaders as the survey data always bases on only a part of the tenants. Furthermore it might appear that the respondent of the survey is not the person who generally logs in the portal. This is not of major relevance as the use frequency detected on the basis of the survey is predominantly relevant for the transparency of the survey data basis.

The results of the impact assessment are presented along the BECA objectives raising ecological awareness, influencing ecological behaviour, and achieving a high satisfaction of end-users.

As the focus of the survey analysis is on the impact of RUAS on behaviour and awareness, all tenants being provided with RUAS are considered as experimental group (whether there is also RMS or not) and tenants without access to RUAS are considered as control group (whether there is also RMS or not).

When assessing the impact on ecological awareness and behaviour by doing pre-post and cross-sectional comparisons – if not stated otherwise – only tenants who participated at both panel stages are included in the analysis in order to get robust results. Furthermore the experimental group is not restricted to the active portal users only, because also the non-active users have been targeted by information campaigns or receive paper reports about their energy consumption in many cases.

The assessment of the motivation of tenants for using the tenant portal or the satisfaction of end-users with the tenant portal and further questions about the tenant portal is realised on the basis of the active portal users who have at least participated in the final survey.

In general and if not stated otherwise, the results were presented by showing proportions (percentages) of the relevant aspects.

The assessment of the impact on ecological behaviour and awareness (based on pre-post comparisons with control group) is structured as follows:

- Percentage before (baseline stage) and after (final stage) the use of the services of the experimental group in relevant categories
- Percentage changes related to experimental group and control group in relevant categories
- Percentage point differences between experimental group and control group after the use of the services (final stage)

The results are discussed under consideration of the initial situation at the baseline stage for experimental and control group and the existing percentage changes. If there are better trends for the experimental group than for the control group obvious this result suggests a net impact of the services. If possible, statistical significances (pre-post comparison and cross-sectional comparison) were assessed by carrying out mean comparisons (t-test). Statistically significant results can be interpreted as net impacts of the services that not caused by chance (whereas this could be the case for not statistically significant results).

2.3 Combined analysis

The general measurement approach consists in the combination of survey and consumption data. This combined analysis allows considering subgroups or identifying possible correlations between variables. By doing so, the results of the consumption analysis might be investigated in more detail. This provides a better understanding of how the achievement of savings is related to further aspects taking into account the perspective of the tenants. This might contribute to the identification of triggers that could be targeted by tenant services such as the RUAS operated in the BECA project.

In general, it is of interest if the ecological awareness and the behaviour of tenants are related to the achieved savings and if the motivation of tenants or their socio-demographic characteristics play a role for their energy consumption or can explain differences between experimental and control group.

The following questions are the most relevant ones for the combined analysis:

- Do tenants with a high ecological awareness (especially high energy saving norm) save more energy than other tenants?
- Do tenants with pro-ecological behaviour actually consume less energy than others?

The realisation of the combined analysis depends on the results of both the consumption analysis and the survey analysis and therefore can differ between the pilot sites. For example, when analysing the relation between ecological behaviour and achieved savings/increased consumption it is most appropriate to analyse if a change of behaviour has led to a certain result in consumption as such a behavioural change serves as driver for a change in consumption. But due to the fact that the number of tenants who reported on a changed behaviour may differ largely in single pilot sites and additionally for those tenants consumption data must be available, such an analysis is not always possible. In this case the behaviour reported at the final survey is considered instead.

Furthermore, each pilot site could reveal special topics of further interest related to the combined analysis. That's why the realised analysis is briefly described in each case in the relevant pilot-specific chapter.

3 Overall results

In deliverable D7.1 the approach for measuring the success of the pilot sites and the whole project has been developed. This approach was based on the common methodology that has been worked out in the course of the ICT PSP Work Programme on ICT for energy efficiency in social housing (which has the EVO International Performance Measurement & Verification Protocol, IPMVP as original basis) and has been enlarged according to the needs of BECA.

Following the common methodology for energy saving measurement that was developed by projects within the ICT PSP programme, theBECA approach reflected a high methodological level of the measurement of the success of the services. The main target was to exclude further unwanted effects that may result from the characteristics of the buildings or tenants involved or from general programme-external factors (self-selection, structural trends, price increases, etc.) and therefore to be able to interpret the savings achieved as net effects or gross effects of the services. Therefore at most pilot sites a control group was established. As explained in more detail in section 2, with help of these sophisticated chosen control groups, externalities are controlled for, but the design does not allow for calculating the single effects of those externalities on the achievement of savings. Comparability of the pilot sites' savings is given by applying the same data collection instruments and procedures for savings calculations, but in doing so, their individual contexts have to be taken into account.

In summary the impact analysis in BECA provides answers about the achievement of the following main targets of the project as a result of the use of ICT for energy efficiency in social housing:

- Do the pilot sites achieve significant resource and energy savings that meet the targets described in D7.1 / D5.2. Do this savings correspond to the objective 1.1 of the ICT PSP work programme 2010 to achieve more than 15% of savings in peak demand and annual consumption of energy?
- Do the pilot sites achieve a significant number of end-users?
- Do the pilot sites achieve a high satisfaction with the RUAS?
- Do the pilot tenants increase their ecological awareness and behaviour due to the RUAS?

Achieved savings

The global savings shown in the following table have been calculated on the basis of the experimental groups by carrying out pre-post comparisons of the dwellings in the cleansed consumption dataset and by using the above described calculation model 2 which is also used by eeMeasure.

As the following table shows, all pilot sites have achieved savings. Many of the pilot sites also met their savings targets as planned and documented in Deliverable D5.2 (resp. D7.2) or are on the right track. Some pilot sites even achieved savings that are going far beyond their a priori defined targets. It is also obvious that the savings vary largely between the pilot sites and with respect to the single resources. This is at least partly due to the different circumstances at the pilot sites (such as building characteristics, energy prices or initial consumptions during baseline period). That's why calculating an average of pilot-specific savings is not useful (and was not targeted in the project).

It has to be pointed out that for some pilot sites it was very ambitious to achieve the expected savings due to the already very low consumption during the baseline period. This topic is discussed in the following pilot site specific sections. Furthermore, especially for social housing tenants it is very difficult to achieve meaningful electricity savings as their incomes are very low and they have only limited capital to replace old electrical appliances by energy efficient ones which would have a bigger impact on electricity consumption than other kinds of behaviour.

In nearly all cases more than 50% of the involved pilot tenants achieved meaningful savings. In half of the cases the percentage of tenants who achieved savings equates even more than 60% (up to 90% in one case). This can be interpreted as great success of the BECA services.

It has to be mentioned that in the case of Örebro the enormous savings of cold and hot water are partly due to a new billing system. The water costs are calculated according to the actual consumption of the tenants now (before it was included in the overall rent). That's why the Örebro tenants have been very responsive to the RUAS provided.

With respect to the BECA project as a whole, about 177 tons CO_2 emissions could be saved which confirms the great success of the services.

Table 3.1: Overview of global results including calculated savings (pre-post comparisons of exp. groups) and reduced Co_2-emissions

Site	Energy type	Savings target in %	Achieved global savings in % (eeMeasure)	Pilot dwellings with savings in %	Reduced CO_2 emissions in $kgCO_2$
Belgrade	Heat energy (RMS+RUAS)	15%	3%	n/a	76
	Cold water (RUAS)		16%	n/a	n/a
	Electricity (RUAS)		4%	58%	7,891
Darmstadt	Heat energy (RMS+RUAS)	6-10%	20%	82%	54,683
	Cold water (RUAS)		7%	56%	n/a
	Hot water (RUAS)		1%	53%	n/a
Havirov	Heat energy (RUAS)	5%	2%	90%	1,643
	Cold water (RUAS)	20%	3%	57%	n/a
	Hot water (RUAS)		1%	66%	n/a
Manresa	Heat energy (RMS+RUAS)	20%	6%	61%	1,513
	Cold water (RUAS)		5%	59%	n/a
	Electricity (RUAS; incl. Peak demand reduction)		increase: 5%	39%	increase
Örebro	Heat energy (RMS)	4-6%	19%	n/a	93,780
	Cold water[1] (RMS+RUAS)	22%	37%	86%	
	Hot water[1] (RMS+RUAS)	7%	35%	86%	
Ruse	Cold water (RMS+RUAS)	10%	8%	62%	n/a
	Electricity (RMS+RUAS)		6%	56%	6,477
Torino	Heat energy	6-10%	Orbassano (RMS+RUAS): 6% Spina 3 (RUAS): 0.4% MOI (RUAS): 7%	Orbassano: 56% Spina 3: 53% MOI: 67%	2,900 (Orbassano, Spina 3) 7,650 (MOI)
	Cold water (RUAS)		1%	51%	n/a
	Hot water (RMS+RUAS)		31%	87%	n/a
Total				39%-87%	177 tons

[1] In addition to RMS and RUAS a new billing system was introduced where costs are now calculated according to the actual consumption of dwellings (before the water consumption expenses were included in the rent)

As mentioned above one target of the evaluation work was to be able to interpret the results with respect to their kind of impact (net vs. gross). Therefore the results of the experimental group have been compared to the results of the control group. The following table shows the results based on the averaged individual percentage changes. It could be stated that in the majority of cases the experimental groups performed better than the control groups. This means that the savings of the experimental groups can be considered as net impacts resulting solely from the services (and not from externalities) – even if they are predominantly not statistically significant.[4] However, it became obvious that the calculation of savings can vary with regard to the used calculation approach (as above described), especially when possible outliers carry more weight when calculating the averaged savings.[5] This is especially true when the sample sizes in the evaluation groups are rather low. This mainly applies to those pilot sites where the experimental groups not always performed better than the control groups. That's why these results should be treated carefully. Furthermore the analysis revealed that the achievement of savings is also depending on the initial situation at the pilot sites. When tenants already consumed very few energy/resources during the baseline period, the potential for the achievement of savings is very low. This applies, for example, to the experimental groups of Manresa where it was very difficult for the experimental tenants to achieve further savings. That's why it can be interpreted as very successful if experimental groups performed better, although they had lower baseline consumption than the control group. That is the case in Ruse (the pilot site focussed on high consumers) and for some resources also in Torino.

One further result is that a RMS seems to have a greater influence on the energy consumption than the RUAS. This can be seen at pilot sites with different experimental groups available (e.g. Belgrade, Darmstadt, Torino).

Table 3.2: Overview of percentage changes in resources / energy consumption related to evaluation groups (approach: averaged individual savings/increased consumption)

Site	Energy type	Initial Situation: higher/lower baseline consumption in exp. group than in control group	Experimental Group RMS	Experimental Group RUAS	Experimental Group RMS+RUAS	Control Group
Belgrade	Heat energy[1]	n/a	n/a	11%	-3.2%	22%
	Cold water[1]	lower	n/a	-16%	n/a	-24%
	Electricity	higher	n/a	-3%	n/a	9%
Darmstadt	Heat energy	exp. RMS: lower exp. RMS+RUAS: higher	-16%	n/a	-15%	3%
	Cold water	higher	n/a	-3%	n/a	3%
	Hot water	higher	n/a	-14%	n/a	-2%
Havirov[2]	Heat energy	n/a	n/a	-3%	n/a	-3%
	Cold water		n/a	-0.4%	n/a	-5%
	Hot water	equal	n/a	-8%	n/a	-1%
Manresa	Heat energy[3]	n/a	n/a	n/a	n/a	n/a

[4] This is mainly due to small sample sizes.

[5] This was discussed in detail in the pilot specific sections.

Site	Energy type	Initial Situation: higher/lower baseline consumption in exp. group than in control group	Experimental Group RMS	Experimental Group RUAS	Experimental Group RMS+RUAS	Control Group
	Cold water	lower	n/a	7%	n/a	2%
	Electricity	lower	n/a	6%	n/a	-4%
Örebro[4]	Heat energy	n/a	n/a	n/a	n/a	n/a
	Cold water	higher[5]	n/a	-26%	n/a	-33%
	Hot water	higher[5]	n/a	-30%	n/a	-35%
Ruse	Cold water	lower[5]	n/a	n/a	0.1%	9%
	Electricity	lower[5]	n/a	n/a	-0.2%	-5%
Torino	Heat energy	Orbassano: higher Spina 3: lower MOI: higher	Orbassano: -8% Spina 3: n/a MOI: n/a	Orbassano: n/a Spina 3: -1% MOI: -5%	Orbassano: -5% Spina 3: n/a MOI: n/a	Orbassano: n/a Spina 3: -1% MOI: -8%
	Cold water	lower	n/a	4%	n/a	9%
	Hot water	lower	n/a	-28%	n/a	-27%

[1] The results are based on building-wise consumption data.
[2] The results are based on a comparison of users and non-users, because there is no control group for heat energy available. With respect to water consumption, data of the control group is only available on a building-wise level.
[3] In Manresa a control group approach was not applicable for heat energy, because consumption data of the control group is only available for the reporting period (heating period 2012/2013).
[4] In Örebro a control group approach was not useful, because tenants of the control group also had access to the tenant portal and in some cases made use of it. That's why the analyses are based on comparisons of portal users and non-users.
[5] Based on consumption (m^3 respectively kWh) in m^2 per dwelling and not per person due to missing information about the household size. Therefore the findings are subject to uncertainty.

Although the comparability of pilot sites with respect to building characteristics was not a focus of the project (also see sections 1 and 2), it is an interesting question whether the impact of the services varies with the energy quality of buildings. When comparing the average savings in relation to the initial baseline consumption, this question can be investigated to some extent. Thereby it is assumed that the energy consumption before operating the services can give some advice as to the energy performance of the buildings. As the energy performance of buildings is mostly relevant for heating, the following figure shows the average savings for heat energy related to the average baseline period heat energy consumption (HDD corrected in kWh/m2/). Related to buildings where RMS and RUAS are provided, a rather clear pattern can be found. Generally, the savings are lower for buildings with lower energy performance according to their baseline consumption. This is especially true when comparing the buildings of Darmstadt and Torino where the same RMS and RUAS technology is provided (Techem adapterm and tenant portal). This means that the influence of services seems to be limited if the energy performance of buildings is rather poor. For example, bigger heat energy losses do exist in badly or not insulated buildings even if the heating system works without malfunctions and in an energy saving manner. At the same time there is lower potential to save energy through optimized energy behaviour of the tenants. It has to be mentioned that the experimental building in Manresa is a somewhat special case because it is the building with the best energy performance (constructed in 2010/2011 with energy efficiency designs) and very new heating system. Additionally, the survey showed that the majority of tenants in Manresa behaved in an ecological manner already before the service

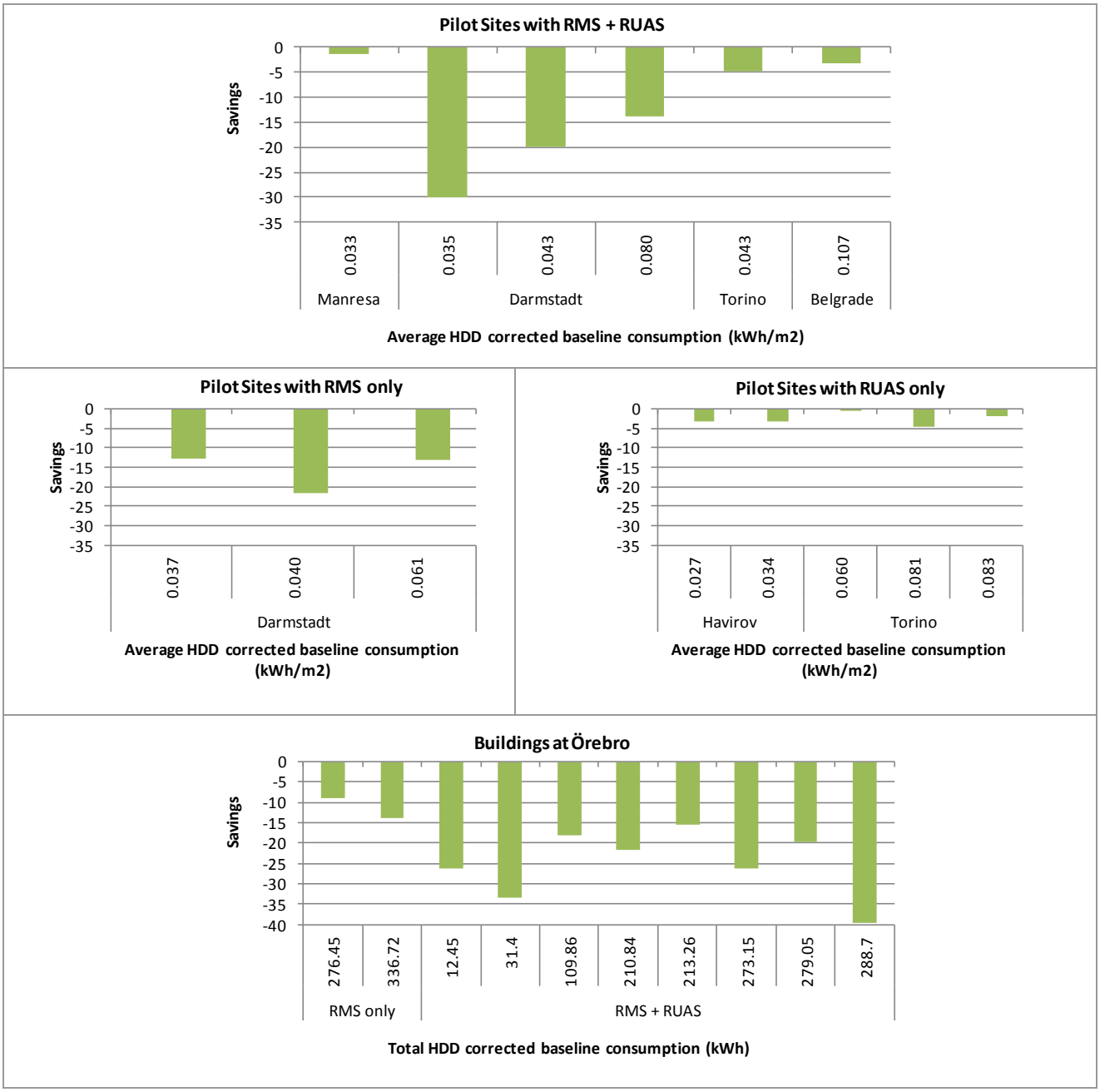
operation (see also section below). These aspects result in a very low savings potential. For buildings with RMS or RUAS and for the buildings at Örebro there is no clear and obvious pattern for the influence of the energy performance of buildings. But it has to be considered that the average baseline consumption is only an approximation for the energy performance of buildings and that many other factors related to buildings and dwellings (location and orientation of the building and the dwelling, building architecture), related to tenants (different behaviours) and contexts at pilot sites (e.g. billing system, cultural aspects, financial situation of tenants, personal motivation to save energy) also have an influence on the baseline consumption and savings. This is also proven by the fact that one building of the Darmstadt and Torino pilot site which have the same average baseline consumption and where the same RMS and RUAS services have been provided, achieved very different savings (-19.8% in Darmstadt; -4.9% in Torino). Furthermore influencing context factors might be the reason for the unclear pattern for the buildings in Örebro. There hot water heating is included in the heat energy consumption values and the consumption analyses for hot water in Örebro showed a large variance of savings in the tenants' households whereby tenants with higher consumption tend to achieve somewhat higher savings than tenants with lower consumption (see Örebro consumption analysis, section 4.5.2). That might be partly reflected on buildings level.

Some more interpretations can be drawn from the results shown below. As already mentioned above, independent from the buildings' energy performance, the RMS seem to have a bigger influence on the savings than the RUAS, but the best solution appears to be the provision of combined RMS and RUAS where the highest savings have been achieved (see especially buildings of Darmstadt with different services). In addition to that, the technologies used for the services seem to have different impacts on the energy consumption. For example, RMS systems that automatically regulate energy related features (e.g. Techem adapterm, setting of limit temperature such as in Örebro), have a bigger impact than systems that serve as monitoring instrument for detecting malfunctions.

Again it has to be emphasized that these interpretations have to be treated carefully, because the different influences (buildings' energy performance, services, technologies etc.) cannot be separated statistically (see also section 2). Therefore multivariate analyses would be necessary which are not possible due to the low number of cases in a pilot study that focussed on developing services for different requirements and testing them under different real conditions. However, some first results on these questions have been found although not having been in the focus of the study and could be further investigated in future research with specific designs to deepen single aspects that have been mentioned in BECA. Due to this great heterogeneity of pilot sites, it is important to apply a sophisticated evaluation design within the pilot sites which was realised with the help of control groups and to apply the same instruments for data collection and savings calculations at all pilot sites as realised in BECA.

In summary, the BECA project showed that influencing the tenants' behaviour by providing feedback is a useful measure independent of the type of buildings and pilot contexts and that savings potential does exist for all of the building types. That's why such low-cost measures and ICT-related energy efficiency services as provided in BECA are useful for all kinds of buildings.

Figure 3.1: Average heat energy savings related to the energy performance of buildings (results of pre-post comparisons in experimental groups)



Achieved number of RUAS end-users

As the following table shows, 1,284 tenant households belong to the RUAS experimental group and therefore are potential RUAS users. This means that they have been equipped with the BECA RUAS and could make use of it. This number of tenant households corresponds to 2,825 individuals (calculated on an average household size of 2.2 persons as described in DoW). These numbers do not include tenant households who belong to the planned control groups within the project (see D7.1).[6] The percentage of tenant households who logged in the portal varies largely

[6] Only in Örebro the initially planned RUAS control group is also included as they also had theoretically access to the tenant portal by using their (already known) password for the homepage of the housing provider (as described in section 4.5.1).

between the pilot sites which is due to different and at some pilot sites difficult circumstances as well as specific and due to data protection issues sometimes complex procedures for receiving a password (e.g. Darmstadt). One third of the total number of potential users became active portal users. That represents an excellent result in the context of social housing. The information was gathered in the portal log-in file at all pilot sites. Considering the fact that many pilot sites additionally offered paper reports or telephone hotline to their tenants the number of active RUAS users is even higher.

In addition to that, the majority (up to 100%) of active users indicated at the final survey that they intend to use the tenant portal regularly in future.

Table 3.3: Overview of the number of portal users (tenant households)

Site	Potential users	Active portal users (measured portal login)	Percentage of active portal users
Belgrade	92	59	64%
Darmstadt	220	7	3%
Havirov	72	28	39%
Manresa	44	44	100%
Örebro	435[1]	177	41%
Ruse	45	26	58%
Torino	376	78	21%
Total	1,284	419	33%

[1] Including tenants of the experimental group and the control group, because the control group also was able to log in the portal.

Level of satisfaction with RUAS

The following table shows the absolute and relative frequency of satisfied portal users. The information is based on the active users who have been identified within the final survey (tenants who logged in the portal at least quarter-annually) and who have answered the question about their satisfaction with the tenant portal in general. As shown in the table, at each pilot site the majority of tenants is satisfied with the tenant portal. In total, 70% of all active portal users across the seven pilot sites are satisfied with the tenant portal which represents an excellent result.

Table 3.4: Overview of the number of satisfied portal users (tenant households)

Site	Number of respondents	Number of satisfied portal users	Percentage of satisfied portal users
Belgrade	26	20	77%
Darmstadt	3	3	100%
Havirov	18	11	61%
Manresa	10	7	70%
Örebro[1]	15	9	60%
Ruse	14	10	71%
Torino	1	1	100%

Total	87	61	70%

[1] Only including tenants of the experimental group, because tenants of the control group have not been asked the question.

Achieved awareness increase and improvement of ecological behaviour

The tenant surveys included questions about the ecological awareness and behaviour of tenants which have been asked in the baseline as well as in the final survey. That's why, in general the changes in ecological awareness and behaviour could be measured in pre-post comparisons of the proportions of tenants who agreed to the single statements.

The following table shows the number and the percentage of statements that show positive trends when comparing the agreement-scores at the baseline survey with the scores at the final survey.[7]

As the ecological awareness was already at a high level at the baseline stage at many pilot sites, and this means a low potential for further increase of awareness, the results are clustered along their awareness level in the baseline survey. The awareness is classified as 'high' if more than 75% of the tenants agreed to the statements in the baseline survey, as 'medium' if 50%-75% agreed and as 'low' if less than 50% agreed to the statements.

Table 3.5: Overview of statements with increased ecological awareness related to initial baseline situation[1]

	Statements with high, medium and low ecological awareness at baseline stage (high = >75% agreement, medium = 50%-75% agreement, low = <50% agreement)			**Statements with increased awareness in experimental group** (for each level at baseline stage)		**Statements with better trends than control group** (for each level at baseline stage)	
	Level of awareness at baseline stage	**N**	**Percentage**	**N**	**Percentage**	**N**	**Percentage**
Belgrade	high	4	57%	2	50%	3	75%
	medium	3	43%	3	100%	3	100%
Darmstadt[2]	Total	n/a	n/a	n/a	n/a	4	57%
Havirov	high	5	71%	4	80%	n/a	n/a
	medium	2	29%	2	100%	n/a	n/a
Manresa	high	4	57%	0	0%	0	0%
	medium	1	14%	0	0%	0	0%
	low	2	29%	2	100%	1	50%
Örebro[3]	high	6	86%	1	17%	2	33%
	medium	1	14%	1	100%	0	0%
Ruse	high	5	71%	2	40%	2	40%

[7] Two statements are not included in this overview, because their interpretation is multi-layered. These are the statements „Energy conservation will restrict my freedom" and „Energy conservation means to live less comfortably".

	medium	2	29%	0	0%	1	50%
Torino	high	5	71%	2	40%	0	0%
	medium	2	29%	0	0%	1	50%

[1] Without statements "Energy conservation means to live less comfortably" and "Energy conservation will restrict my freedom".
[2] For Darmstadt pre-post comparisons are not possible due to small sample sizes. In the last column are reported statements with higher awareness in the experimental group than in the control group at the final survey.
[3] For Örebro the results in the last column are based on the comparison of users and non-users.

The table shows that the awareness increased predominantly related to statements with medium or low awareness in the baseline survey. However, all pilot sites achieved an increase of awareness for at least some statements. This has to be interpreted as very promising result especially considering that at each pilot site more than half of the statements already showed a high level of awareness at the baseline stage and therefore the potential for further increase is low.

The table also reveals that in many cases the trends in the experimental groups are even better than in the control groups. This indicates that the RUAS has a meaningful (net) impact on the ecological awareness of tenants.

Table 3.6: Overview of statements with improved ecological behaviour related to initial baseline situation[1]

	Statements with low, medium and high level of ecological behaviour at baseline stage (high = >75% agreement, medium = 50%-75% agreement, low = <50% agreement)			**Statements with improved behaviour in experimental group** (for each level at baseline stage)		**Statements with better trends than control group** (for each level at baseline stage)	
	Level of ecological behaviour at baseline stage	**N**	**Percentage**	**N**	**Percentage**	**N**	**Percentage**
Belgrade	high	8	62%	1	13%	2	25%
	medium	4	31%	2	25%	3	38%
	low	1	8%	0	0%	0	0%
Darmstadt[2]	Total					5	42%
Havirov	high	9	69%	9	100%	n/a	n/a
	medium	1	8%	1	100%	n/a	n/a
	low	3	23%	3	100%	n/a	n/a
Manresa	high	9	69%	2	22%	3	33%
	medium	2	15%	0	0%	0	0%
	low	2	15%	1	50%	1	50%
Örebro[3]	high	7	54%	2	29%	2	29%
	medium	4	31%	1	25%	1	25%
	low	2	15%	2	100%	1	50%
Ruse	high	9	69%	5	56%	4	44%
	medium	2	15%	2	100%	2	100%
	low	2	15%	1	50%	2	100%
Torino[4]	high	10	83%	1	10%	3	30%
	medium	2	17%	0	0%	1	50%

[1] Without statement "I mostly tumble dry my clothes" due to small sample sizes.
[2] For Darmstadt pre-post comparisons are not possible due to small sample sizes. In the last column are reported statements with higher awareness in the experimental group than in the control group at the final survey.

[3] For Örebro the results are based on the comparison of users and non-users.
4 The results are basing on a total of 12 behaviour statements as the statement “My room temperature at night is usually lower than by day” is excluded due to an automatic night setback available at the majority of buildings.

With regard to the ecological behaviour (shown in the above table) the RUAS also reveal many positive influences. As already obvious for the ecological awareness, the tenants mostly had an already high level of ecological behaviour at baseline stage. However, all pilot sites succeeded to help their tenants to improve their behaviour once again for a part of those statements. In the same at least quarter of cases the trends in the experimental group are better than in the control group which indicates a net impact of the services. Nevertheless, the influence of the RUAS generally becomes more obvious when tenants initially had a medium or low level of ecological behaviour. In these cases the relative frequency of statements with improved behaviour in the experimental group is higher and/or the level of improvement is higher. At the same time, there are more often better trends for the experimental group than the control group.

This means that the services deploy their impact especially for tenants who have initially lower levels of ecological behaviour. The fact that they also succeeded in cases with low potential for improvement is considered as very promising result. In total, the tenants of the experimental group achieved better trends than the control group related to 31%-62% of all behaviour statements. This can be interpreted as great success of the services especially when considering that one year is a rather short time period for making tenants change their behaviour.

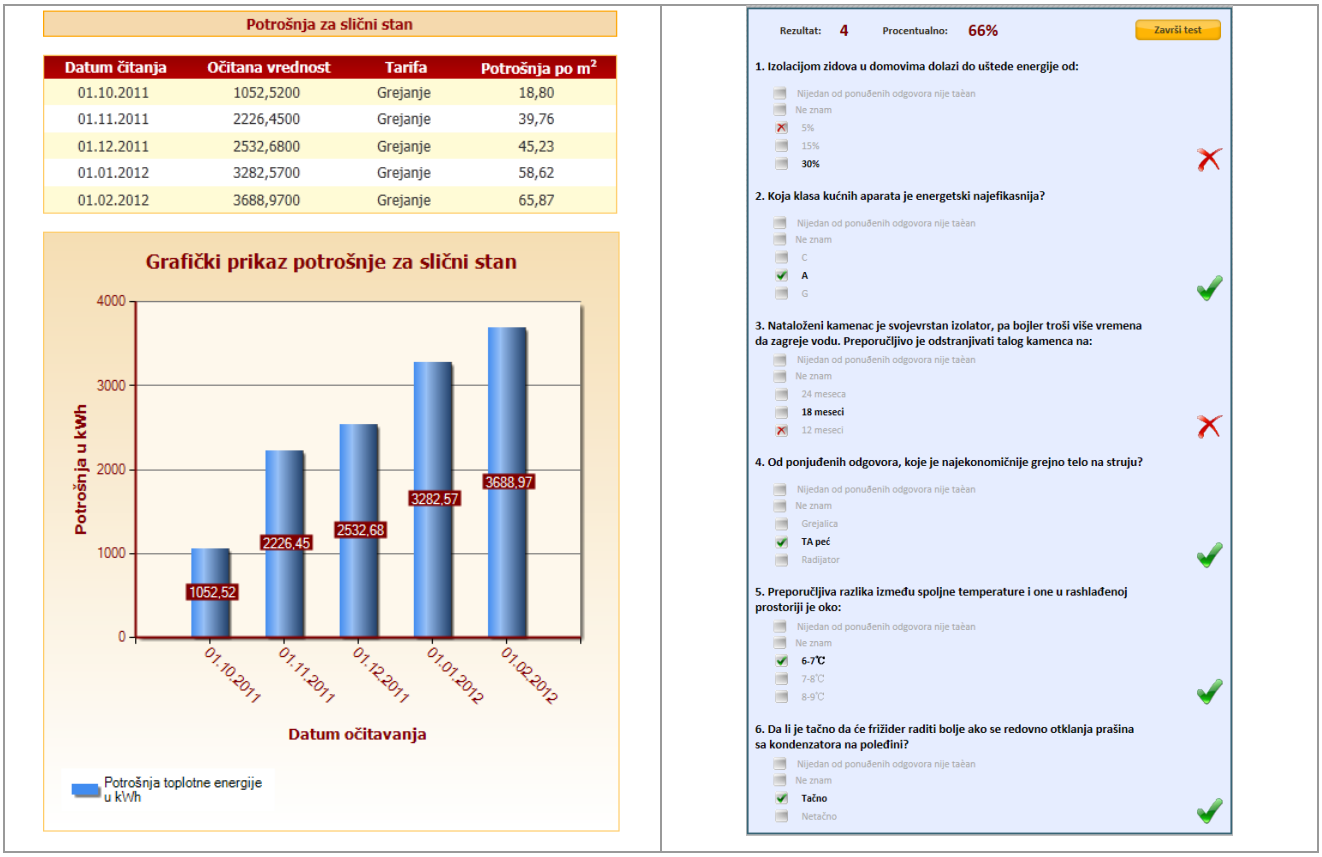
4 Pilot site-specific project results

4.1 Belgrade

4.1.1 Background information

The Belgrade RUAS is operated including heat energy, cold water and electricity consumption. The service consists of a tenant web portal giving tenants feedback about their household's consumption. There are included daily (heating) and monthly (electricity, water consumption) consumption reports as well as comparative (comparison of energy consumption with similar dwellings) and historical feedback (comparison with previous time periods). Furthermore the RUAS provides energy/resource saving tips and includes a self-assessment tool (e-testing). By means of the self-assessment tool tenants can test their knowledge about energy saving issues which should motivate and enable them to optimise their consumption behaviour. In addition to that, tenants received several educational materials. Tenants living in Tower A could additionally make use of a service hotline.

Figure 4.1.1: Screen shoots of RUAS tenant portal (left: consumption feedback, right: self-assessment tool) in Belgrade



The Belgrade RMS is related to the monitoring of heat energy consumption (changed from coal to solid biomass). Therefore, in one of the buildings (Tower A) new metering equipment was installed in order to control the heat demand of the building and to detect malfunctions of the heating system. The operation of the heating system was additionally optimised by taking into account the outside temperature which is also measured.

RUAS and RMS started operation in October 2012 - after a one-year baseline consumption measurement (Nov 2011 – Oct 2012) and followed by a one-year reporting period (Nov 2012 – Oct 2013). That allows pre-post-comparisons based on the analysis of the evolution of the

consumption figures resp. the in tenant surveys reported behaviour patterns/attitudes before and after the implementation of the service. The comparably 12-month lengths of both the baseline and the reporting period enable to have a good consistency of consumption data.

In addition to that, the Belgrade pilot evaluation followed a control group approach. In total, 184 dwellings in three buildings (Towers A-C) were part of the BECA project – half of them belonging to the experimental group (related to heating with two different setups), the other half belonging to the control group.

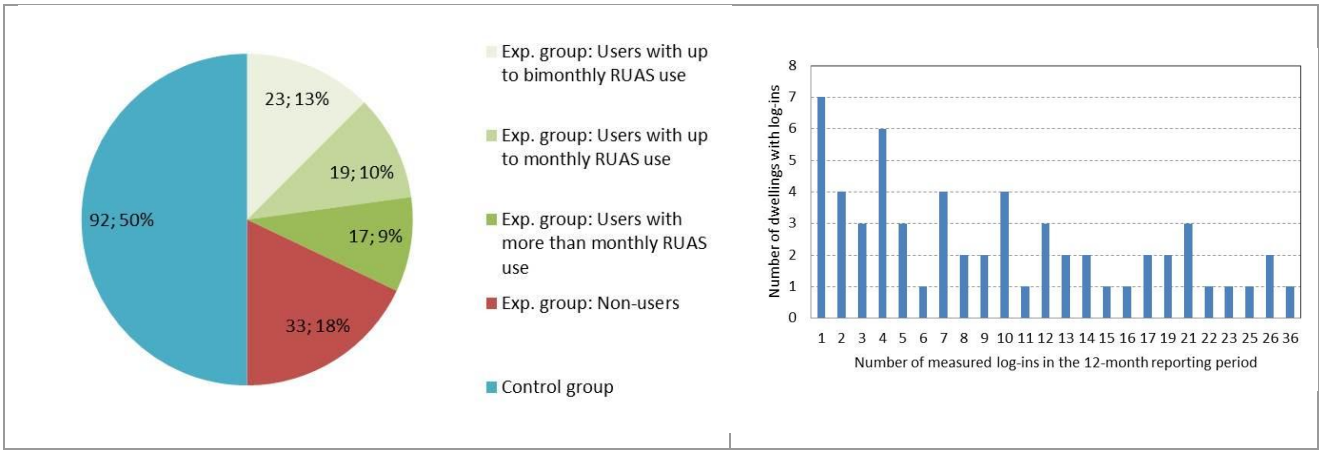
Table 4.1.1: Basic population of pilot dwellings belonging to experimental and control group

Group Status	Tower A	Tower B	Tower C	Total
Experimental group RUAS	x	x		92
Experimental group RMS (heating only)	x			
Control group RUAS			x	92
Control group RMS (heating only)		(x)[8]	x	
Dwellings with measurements	46	46	92	184

Tenant recruitment in Belgrade was realised by using different means such as posters, brochures, newsletters, face to face meetings and information via internet to inform tenants about the project. In addition to that, a training meeting took place in coordination of the president of the tenant assembly and further meetings with presentations were arranged (for further details see D.5.2).

Tenants of the experimental group who were interested in the RUAS and that's why logged in the web portal have been counted as users. Those who didn't log in were counted as non-users. The analysis of the measured portal log-ins showed that nearly two thirds of the experimental group (64%) used the RUAS more or less regularly – in a range from at least once per year up to thrice monthly. The average portal use frequency was 10.1 times in 12 month (standard deviation: 8.1).

Figure 4.1.2: Tenant groups and measured log-ins of RUAS users



According to the report of the pilot site manager, the majority of tenants, who received a password but did not log in, have no computer and/or no internet connection available. Most of those tenants used the hotline service in order to get consumption data and some tips on saving energy.

[8] In general, the evaluation design in Belgrade should allow for identifying the impact on heat energy consumption caused solely by RMS resp. solely by RUAS. But due to the below described restrictions of apportioned building-wise measurements, it is difficult – or impossible – to separate both effects accurately.

4.1.2 Results of consumption analysis

In Belgrade the consumption data analysis is related to cold water, heat energy and domestic electricity used for water heating with individual boilers, household appliances and lightning.

Electricity consumption was measured at a dwelling-wise level. Related to heating and cold water, the measured building-wise consumption data were allocated to all dwellings in equal measure based on their surface area resp. number of persons living in the dwellings. That means for analysis that a dwelling-wise calculation of individual savings is not effective for heating and cold water due to the fact that all dwellings in one building achieved the same savings resp. the same consumption increase.

Table 4.1.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	building-wise*
Electricity	kWh	daily/monthly	dwelling-wise
Cold water	m^3	monthly	building-wise*

* Apportioned to all dwellings in equal measure

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. In doing so, changes of tenancy[9] did not occur, but 20% of the dwelling-wise measured electricity data – provided by the Electricity utility company – has to be excluded from an analysis because of incomplete datasets with several month of zero data mainly due to power cut-offs because of outstanding debts. The number of dwellings included in the consumption data analysis is shown in the following table.

Table 4.1.3: Overview of the number of buildings and dwellings involved in the Belgrade pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Belgrade	3	184	Heating: 184 (exp. 92+contr. 92) Electricity: 148 (79+69) Cold water: 184 (92+92)	Electricity: 36 dwellings (20%) due to missing data of several months

Global results

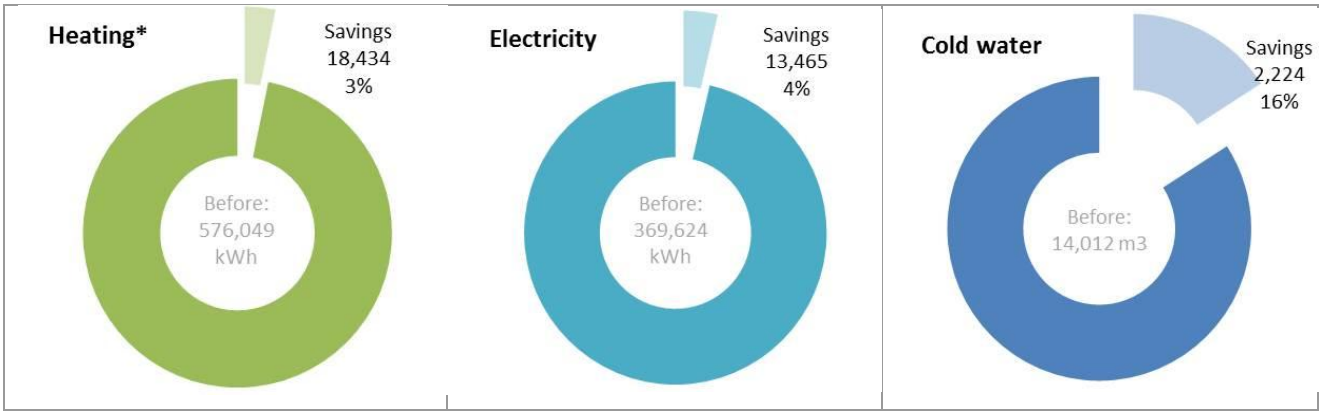
The calculation of global savings following a pre-post comparison led to the results shown in the following figure. The experimental group achieved total savings of about 3% heating (related to Tower A only, n=46), 4% electricity and 16% cold water (each n=92). That equates to savings of more than 18.4 thousands kWh heating, nearly 13.5 thousands kWh electricity and more than 2.2 thousands m^3 water. Compared to the target setting of 15% savings in total prior to the project (see D5.2), that goal could be overachieved related to cold water. The good results related to heating and electricity show a positive trend when using the services which could be very likely improved in the future.

In deviation to the above described analysis methodology, the global savings related to heating and cold water could not be calculated with eeMeasure because these consumption data were available on a building-wise level passing on costs to all dwellings using an equal allocation formula (as explained above). Related to heating, for example, where temperature adjustments are necessary to take into account climatic effects when comparing different heating periods,

[9] Reported by the pilot site manager

eeMeasure uses a regression model with the heating degree days (HDD) as a predictor. Such a regression model is not appropriate in cases of only three building-wise data.

Figure 4.1.3: Overview of global results of the experimental group in Belgrade



* Related to Tower A only (n=46) with both RMS and RUAS; for more details see the specific heating chapter below

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

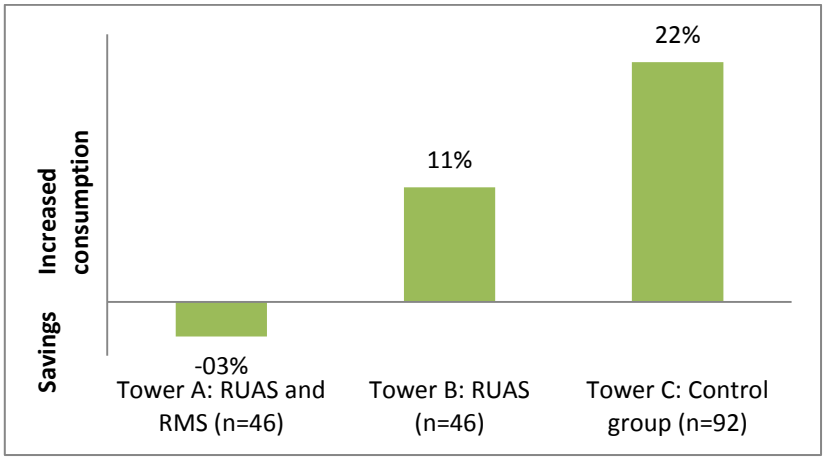
Table 4.1.4: Overview of global CO_2- and cost savings of the experimental group in Belgrade

Energy / resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy	0.0041 kg CO_2/kWh	76	0.15 €/ kg biomass	569
Electricity	0.586 kg CO_2/kWh	7,891	0.0614 €/kWh	827
Cold water	n/a	n/a	0.55 €/kWh	1,223
Total		**7,967**		**2,619**

Heating

Beside the availability of apportioned building-wise data, a further specific characteristic of the evaluation design related to heating in Belgrade was that the experimental group was divided into two sub-groups: In both sub-groups tenants could make use of the RUAS tenant portal, but only Tower A was additionally operated with a RMS.

Figure 4.1.4: Percentage change in heating consumption related to comparison groups



The above figure shows that the RMS had the biggest impact on the reduction of heat energy consumption: While in Tower A, additionally operated with RMS, savings of more than 3% has been achieved, in Tower B with RUAS only the consumption increased by nearly 11%. However, when comparing Tower B with the control group in Tower C also a positive effect of RUAS becomes obvious because the control group has a much higher consumption increase than the experimental group in Tower B.

Electricity

As the following table shows, the composition of the experimental resp. control group is partly divergent: The dwellings of the experimental group are on average larger than in the control group. Especially the RUAS users more often live in single- and two-person households than non-users. Compared to the control group with a similar average household size, RUAS users have a higher net dwelling area per person.

Table 4.1.5: Household/dwelling characteristics of experimental and control group

Characteristics	Experimental group			Control group (n= 69)
	Users (n=51)	Non-users (n=28)	Total (n=79)	
Percentage of single-households	29	11	23	22
Percentage of two-person-households	33	39	35	42
Percentage of multi-person-households	37	50	42	36
Average household size	2.4	2.9	2.6	2.3
Average net dwelling area in m^2	51	52	51	46
Average net dwelling area in m^2/person	28	23	26	23

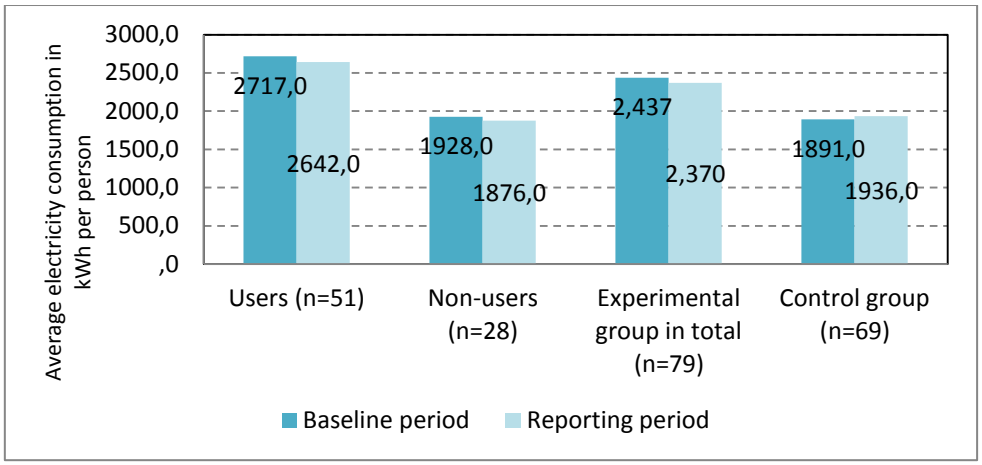
Both characteristics – smaller households in bigger flats – lead to significantly higher electricity consumption figures per person. The analysis showed a clear and statistically highly significant correlation between the available net dwelling area per person and the electricity consumption per person.[10] On the one hand that is due to a basic equipment of big electrical appliances as washing machine, cooker, fridge, etc. which is usually available in single households as well as in multiple-

[10] Baseline period: r = 0,701 (p < .01); reporting period: r = 0,680 (p < .01)

person households similarly. On the other hand, bigger flats often motivate their inhabitants to have more or bigger appliances than others because of more available surface area.

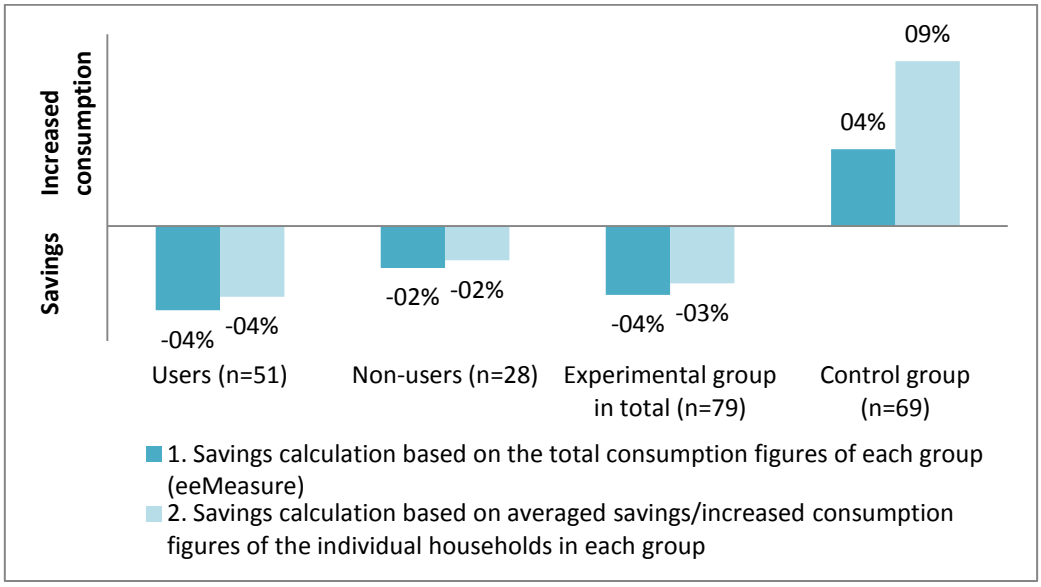
The comparably high household electricity consumption seems to be a main reason for becoming a user of the offered RUAS (see following figure). In the present case, the average baseline electricity consumption (in kWh per person) of the whole experimental group was about 29%, of the actual RUAS users even about 44% higher than the average consumption of the control group.

Figure 4.1.5: Average electricity consumption in kWh/person in baseline and reporting period



The realised pre-post comparison showed electricity savings in the experimental group – especially for the actual RUAS users – and increased consumption in the control group (see following figure).

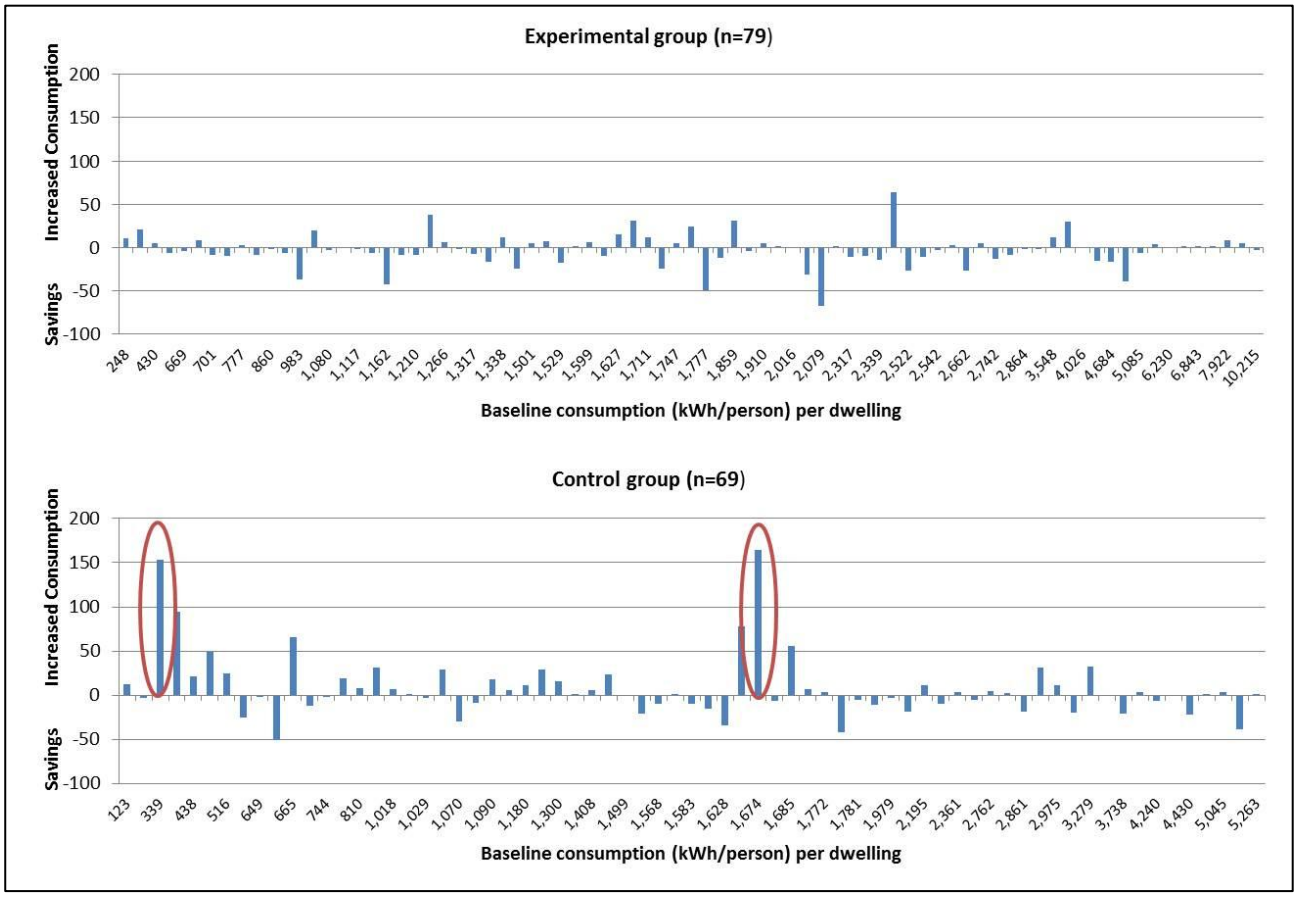
Figure 4.1.6: Percentage change in electricity consumption related to comparison groups



As explained in the introductory chapter both used approaches for calculating the savings can lead to divergent results. In the present case, such a divergence is especially relevant for the control group, but it is – on a smaller level – also obvious in the experimental group. The reasons for that are illustrated in the following figure: There are two households belonging to the control group (marked in red) who had a very low resp. obviously below average baseline electricity consumption and whose consumption level turned into rather normal, but still low consumption in the reporting period. That means for calculating, that their low absolute consumption figures do not carry weight related to the total consumption of the control group (calculation model 1), but they carry weight

when using calculation model 2 due to their immensely relative consumption increase of more than 150%. Those consumption characteristics are not necessarily abnormal – especially when taking into account the obviously low income population underlined by the high percentage of power cut-offs described above. For example, it is possible that these households had a longer period of absence or did not use big appliances (e.g. they do not have a freezer or a washing machine, do not cook, shower with cold water only), etc.

Figure 4.1.7: Savings resp. increased consumption per household (in %) related to the baseline electricity consumption (in kWh/person)[11]



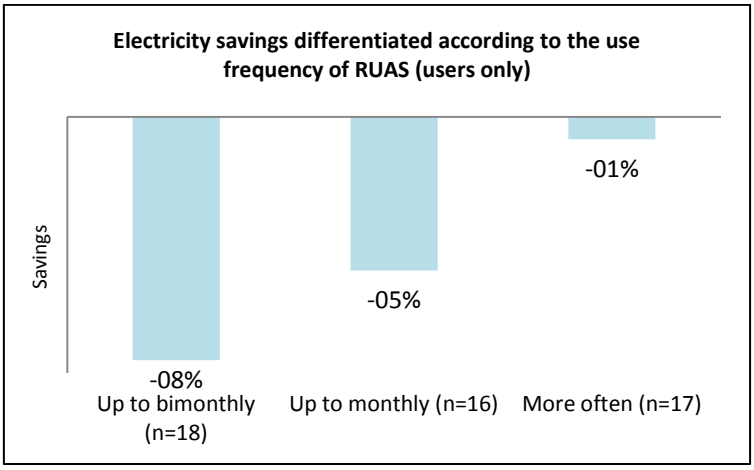
However, figure 4.1.6 showed that the households of the experimental group achieved average savings of 3%, while the average electricity consumption of the control group increased by 8.6% in the same observation period. That difference, which is statistically significant ($p<.05$, calculated with t-test), evidence the positive impact of RUAS on electricity saving.

In contrast to the tenants of the control group who did not receive any information regarding the RUAS tenant portal, the non-users of the service have been provided with BECA information brochures, etc. and were invited to become users as well. So it can be assumed that non-users also became aware of the project aim to save energy. That could be a possible explanation for their average savings of 1.8%.

Tenants who used the RUAS more or less regularly achieved the largest average electricity savings of 3.7% - even though the frequency of portal use seems to be not of explanatory power for the amount of the savings: Those tenants who logged in rather seldom achieved better savings than those with a higher number of log-ins.

[11] The consumption figures are always sorted in ascending order from left to right.

Figure 4.1.8: Electricity savings of the RUAS users with special focus on their use frequency



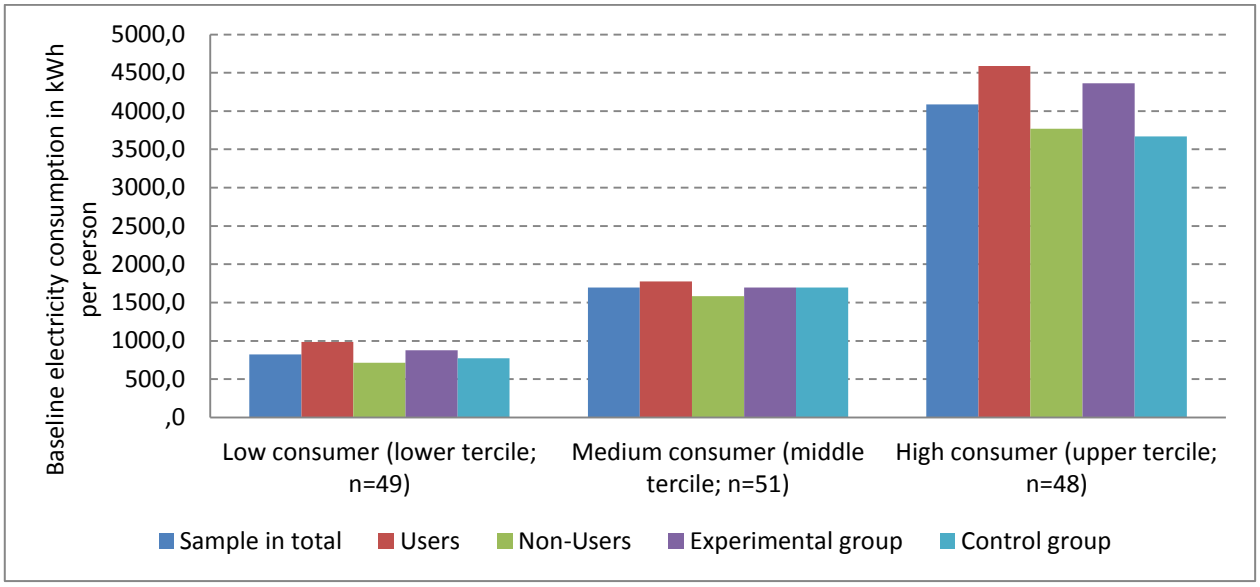
The majority of households in the experimental group (58%) achieved individual electricity savings. On average these households saved nearly 14% electricity compared with the baseline period. More than half of the households of the control group (55%) consumed more electricity in the reporting period – on average they had an increase of more than 27% compared to the baseline.

Table 4.1.6: Percentage of dwellings with electricity savings/increased consumption and correspondent average figures related to the comparison groups

	Experimental group			Control group
	Users	Non-users	Total	
Percentage of dwellings with savings	57	61	58	45
Average savings of dwellings with savings	-16.9	-8.8	-13.8	-14.6
Percentage of dwellings with increased consumption	43	39	42	55
Average increased consumption of dwellings with increased consumption	+13.2	+9.1	+12.1	+27.5

It was of further interest to answer the question if the baseline consumption level has an influence on the achieved savings. Therefore, the sample was divided into terciles based on the baseline consumption figures of the whole sample. The following figure shows the average baseline consumption in each tercile related to all considered comparison groups.

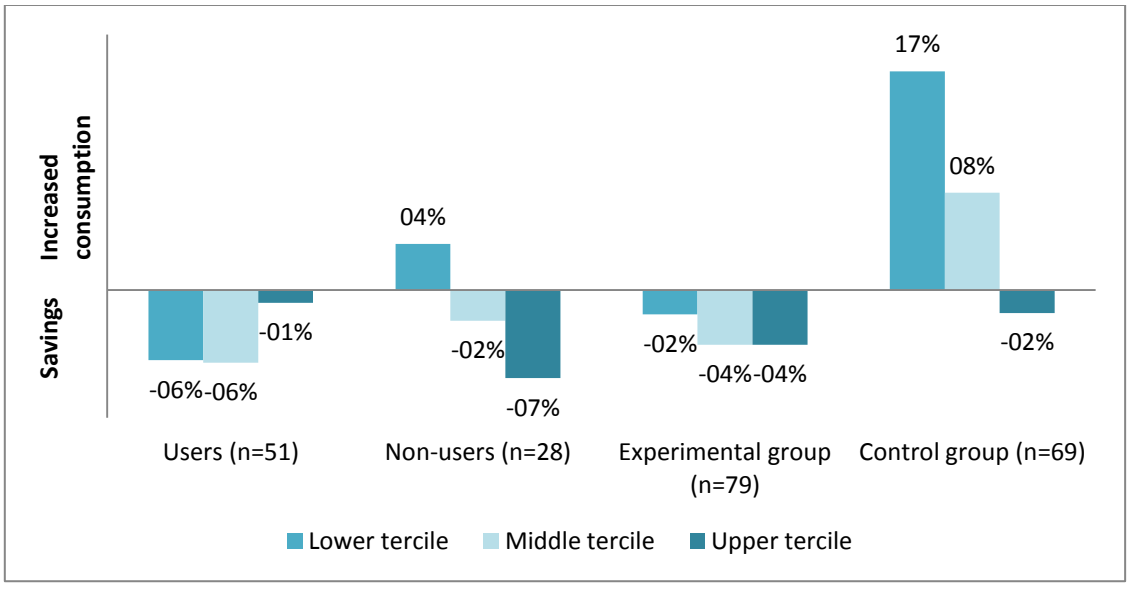
Figure 4.1.9: Average baseline electricity consumption (in kWh/person) of the consumption terciles



The analysis shows that the experimental group in total achieved savings in all terciles. That means that high consumers reduced their consumption as well as those households with already low or medium electricity consumption figures. Related to the experimental group as a whole, the highest savings were achieved in the middle and in the upper tercile. Related to the control group, only the high consumers had a consumption reduction of nearly 2%.

Nevertheless, related to the total sample the analysis of differences between the three terciles with regard to their percentage change in consumption showed no statistical significance.

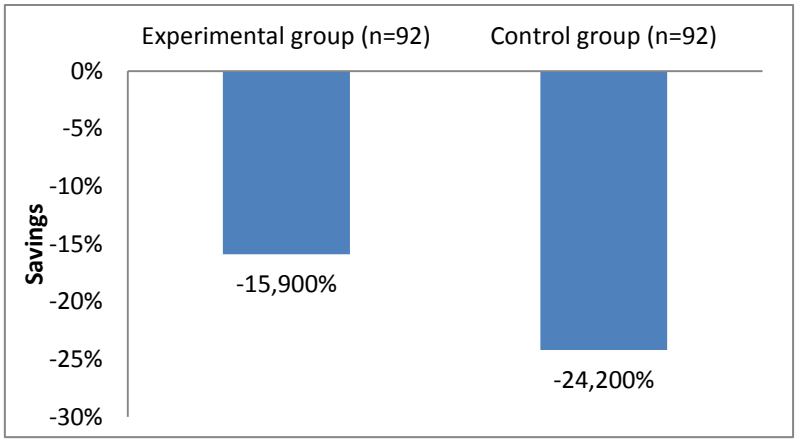
Figure 4.1.10: Percentage change in electricity consumption related to consumption terciles in each comparison group



Water

Related to cold water in Belgrade only building-wise data were available which were apportioned to all dwellings following an equal allocation formula. The data analysis showed that both comparison groups achieved significant savings, the control group (24% savings) even more than the experimental group (16%).

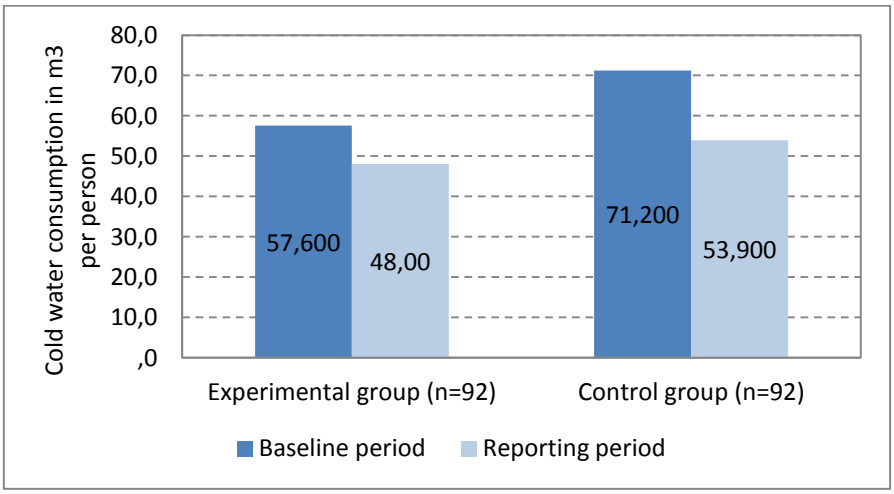
Figure 4.1.11: Percentage change in cold water consumption related to comparison groups



Nevertheless, in absolute terms the tenants of the control group consumed more cold water than those in the experimental group. In the baseline period the control group had a 24% higher water consumption per capita than the experimental group. In the reporting period this difference was still 12%. That implies that the tenants of the experimental group had already comparably low water consumption, handled already water conscious in the baseline and intensified their efforts in the reporting period supported by RUAS.

However, the water consumption of the pilot population as a whole is below the Belgrade average of 0.25 m^3 per person and day (ca. 91 m^3 per person and year).

Figure 4.1.12: Cold water consumption in m^3 per person related to comparison groups



4.1.3 Results of survey analysis

Results of mid-term survey

In Belgrade 19 tenants have been interviewed about their experiences with the tenant portal

The results of the mid-term survey mostly include positive feedback of the tenants. Only one household described the handling of the tenant portal as a whole as not easy. For 90% of respondents the images and graphics are easy to understand. Asking about what could be improved related to the portal, a large majority answered that the portal is very good and there is nothing to change. In that context two households suggested an easier handling, one household called for animation and one for a different colour selection. Except one household, all others affirmed that they improved their knowledge by using information provided by the portal. No household reported on technical problems with the tenant portal. The question dealing with a description of the portal used four adjectives for an individual assessment: Successful, good, helpful and informative. Especially the characteristics “helpful” and “informative” were taken for granted. On average each household logged in four times a month in the tenant portal. In most of the households (13 of 19) the other members of the household also know the tenant portal and some of them also use it. 90% of respondents said that it is easier for them now to understand the energy consumption bills. Almost as many (85%) believe that the tenants can use the portal to save energy. Except one household, all the others mentioned that they have already tried to implement the portal energy saving tips. All things considered, the tenants were very satisfied with the tenant portal - a household advised to do advertisement in the media with the portal, one household promised to advertise it in his social environment itself.

Data basis and profile of respondents at baseline and final survey

The following table shows the number of respondents related to the survey stages. In the baseline survey participated 37% of the invited control group (34 tenants) and 36% of the tenants provided with RUAS (33 tenants).

At both panel stages participated 29 tenants belonging to the control group (32%) and 28 tenants belonging to the experimental group (30%). They will be included in pre-post and cross-sectional comparisons. Questions about the tenant portal will be analysed on a basis of 29 respondents of the experimental group who participated at least in the final survey.

Table 4.1.7: Number of respondents per survey stage

Participation at survey stage	Evaluation Group		Total
	Control Group	Experimental Group (RUAS)	
Only baseline survey	5	5	10
Only final survey	0	1	1
Baseline and final survey	29	28	57
Total	34	34	68

Based on data of tenants who participated in both panel stages, some differences in the profile of control tenants and experimental tenants become obvious. Whereas the majority of control group respondents are female, it is the opposite way round for the experimental group. In addition to that experimental group respondents are older than respondents of the control group.

Quite similar characteristics can be found with regard to the size of the household (3 persons) and the level of education, although the control group tenants are slightly higher qualified. Experimental group respondents show somewhat shorter time periods when nobody of the household is at home as respondents of the control group. All respondents of both groups are born in Serbia and do not

receive any financial support by the municipality. Differences in both groups can influence the interpretations resulting from cross-sectional analysis, but are not relevant when doing pre-post comparisons.

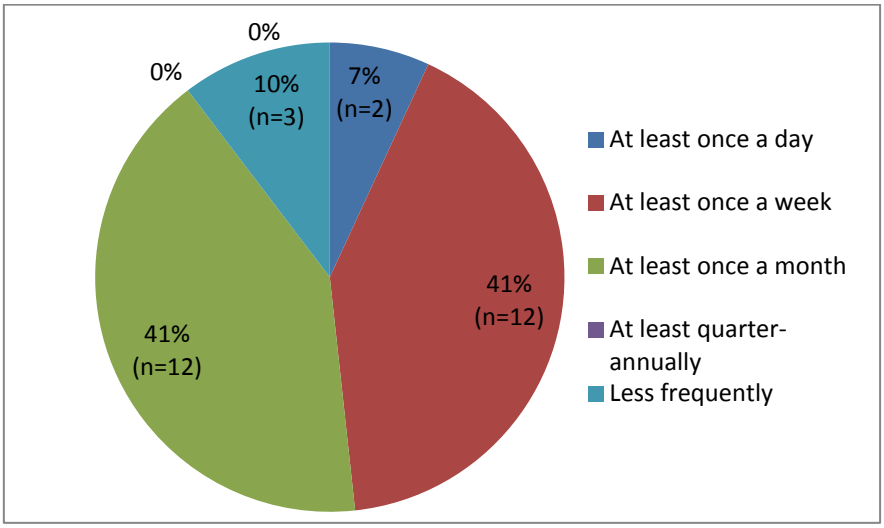
Table 4.1.8: Profile of respondents in relation of survey participation

Characteristics (based on answers in final survey)		Final		Baseline and Final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
Sex	Male	12 41.4%	18 62.1%	12 41.4%	17 60.7%
	Female	17 58.6%	11 37.9%	17 58.6%	11 39.3%
Country of birth	Serbia	29 100.0%	29 100.0%	18 100.0%	18 100.0%
	Other	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Age	Mean	50 years	57 years	50 years	57 years
	Median	48 years	56 years	48 years	56 years
Level of education	No school leaving qualification	1 3.4%	0 0.0%	1 3.4%	0 0.0%
	Primary/secondary school leaving qualification	2 6.9%	2 7.1%	2 6.9%	2 7.4%
	Secondary school leaving qualification	13 44.8%	16 60.7%	13 44.8%	16 59.3%
	University entrance qualification	1 3.4%	1 3.6%	1 3.4%	1 3.7%
	University/university of applied science degree	12 41.4%	8 28.6%	12 41.4%	8 29.6%
Size of household	Median (persons)	3	3	3	3
Absence of all household members at normal week day	0-2 hours	9 31.0%	14 48.3%	9 31.0%	14 50.0%
	3-5 hours	7 24.1%	8 27.6%	7 24.1%	8 28.6%
	6-8 hours	11 37.9%	7 24.1%	11 37.9%	6 21.4%
	More than 8 hours	2 6.9%	0 0.0%	2 6.9%	0 0.0%
Rent or service Charges paid by municipality	No	100.0%	100.0%%	100.0%	100.0%

RUAS use and motivation of tenants

All respondents of the final survey had already heard from the tenant portal and are registered portal users, but three of them cannot be classified as active users, because they logged into the portal semi-annually (1 person) or even less frequently (2 persons). Active users are defined as persons making use of the portal more regularly (at least quarter-annually). The following figure shows that the majority of the survey respondents have used the portal at least once a month or at least once a week which is a high usage rate. Two respondents even logged at least once a day. Due to this frequent use of the portal, an impact of RUAS on the ecological behaviour and awareness should be noticeable.

Figure 4.1.13: Frequency of portal use
(n=29; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

The social structure of the 25 active users of the portal who participated in both survey stages is very similar to the profile of all survey participants (see Table 4.1.8) as only three of them are not using the portal actively. The majority is male (15 male users, 10 female users). The age structure of users is covering a big range between 29 and 82 years and nearly all users have got an internet access at home.

Before starting the RUAS services, the motivation to save energy consists predominantly in saving money and protecting the environment equally. 66% of control group tenants and 54% of experimental group tenants have this opinion.

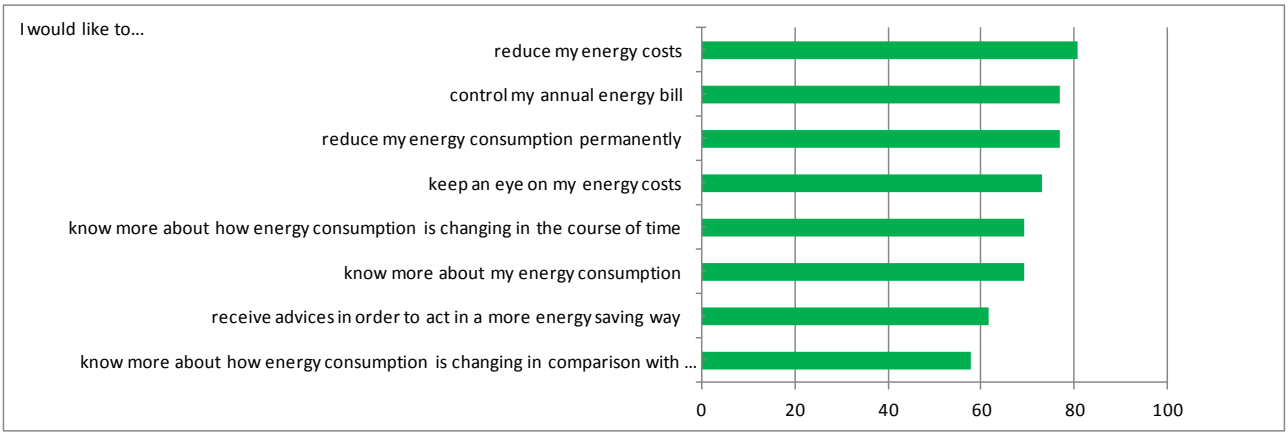
The environmental aspect is not gaining relevance during the services; on the contrary the money saving aspect gets more important. At the final survey stage 54% of experimental group tenants state that their motivation for saving energy solely consists of saving money (at baseline stage 21% had this opinion). As the control group shows the same trend (45% at final stage vs. 10% at baseline stage) this is not resulting from the services, but seems to be a general trend.

Reasons for using the tenant portal

Figure 4.1.14 shows the reasons for using the tenant portal ranked by answer category “I strongly agree”. It is obvious that a reduction of energy costs is the driving reason (81% strongly agree, 19% rather agree) followed by the control of the annual energy bill and to reduce energy consumption permanently (both 77% strongly agree and 23% rather agree). On the other hand just to know more about the energy consumption taken by itself or its change over time is seen as less relevant (69% strongly agree) whereas nearly two third of the users state that would like to keep an eye on the energy costs (73% strongly agree.) Somewhat striking are the lower agreement scores

for receiving advices in order to act in a more energy saving way (62% strongly agree) although many users would like to reduce their consumption and energy costs. Maybe they cannot imagine that they still can learn from such advices in order to achieve these aims. Receiving feedback about how their energy consumption is changing in comparison with other household is the less relevant reason for using the portal, but still 58% of the users fully agree to this motivation.

Figure 4.1.14: Reasons for using the tenant portal
(n=26; active users; percentages for "I strongly agree")



Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

Impact on ecological awareness

To raise the ecological awareness of tenants was one objective of the BECA services. That's why information about attitudes, opinions and knowledge about energy saving issues were gathered in the survey.

The following figure shows changes of the ecological awareness for the experimental group based on the sample of 28 persons who participated in both survey stages (answer categories "strongly agree" and "rather agree" together).[12]

It becomes obvious that there is already a high level of awareness before the RUAS use. Issues about the general importance of protecting the environment and issues about personal needs to save energy at home find high consent from more than 90% of the tenants. After the use of the tenant portal those high percentages decrease a little bit, but still stay at a high level of at least 75%.

An opposite trend is seen for statements that personally address the tenants. The personal interest of tenants in their energy consumption at home and in possibilities for saving energy at home are already at high levels before the portal use (93% each), but still raise up to 96% for both statements. The conviction that tenants should save more energy at home shows an increase from 72% to 89%. So, the portal helps tenants to see that they personally should and can do something to save energy at their homes.

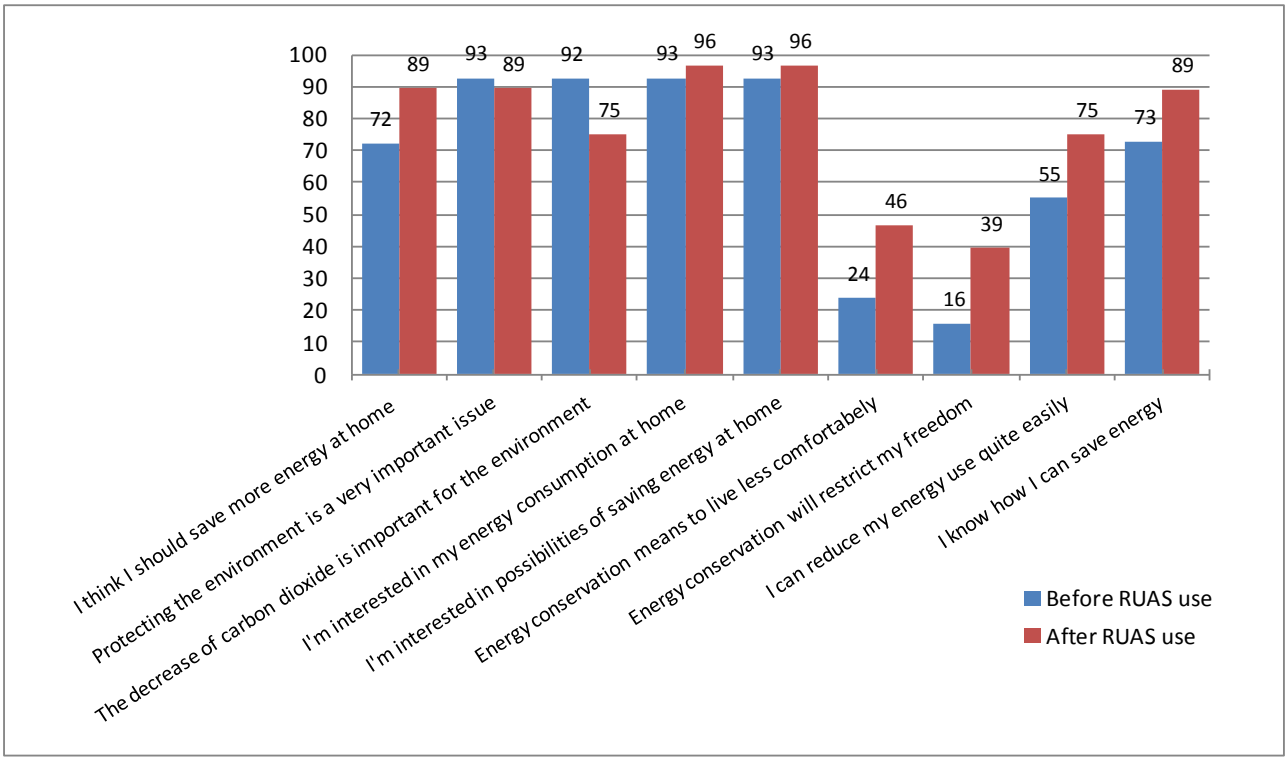
It can also be noticed that the knowledge about how to save energy at home is much lower before the RUAS use than after it. So 73% stated to know how to save energy prior the portal use whereas this percentage rises to 89% in final stage.

On the other hand it is found that negative aspects such as restriction in freedom and comfort become more relevant after the use of the services. This means, energy saving actions are

[12] For some statements the sample is somewhat smaller due to missing values.

considered as necessary and important, but also as restricting elements in everyday life. Nevertheless, the reduction of energy use is assessed as quite easily. The agreement on this statement raises form 55% to 75% at final stage.

Figure 4.1.15: Ecological awareness of experimental group tenants before and after RUAS use
(n=25-28 due to missing values); percentages for answer categories “strongly agree and rather agree”)

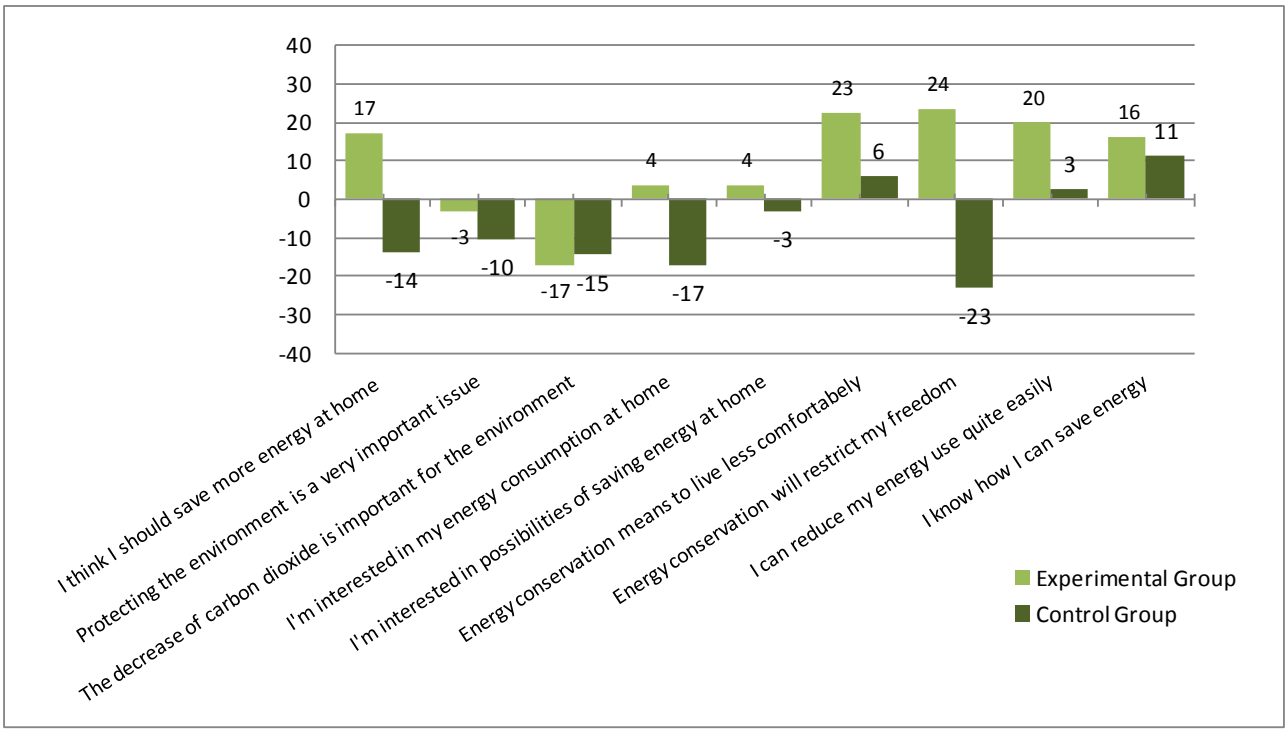


Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don’t know.

For a correct interpretation of these results regarding the net impact of RUAS it is necessary to examine the development in the control group at the same time. The following figure shows the percentage changes in the experimental group and control group. By doing so, the trends of both groups can be compared.

The comparison shows that the trends in the experimental group are better for almost all items. This means that positive trends either are stronger or negative trends are weaker than in the control group. For statements related to personal convictions or interests (“I think I should save more energy at home”, “I’m interested in my energy consumption at home”, “I’m interested in possibilities of saving energy at home”) there can be found positive trends for the experimental group, but negative trends for the control group. These are strong indicators for a net effect of the RUAS services. Nevertheless, it becomes obvious that raised interest and knowledge about how energy can be saved go along with a stronger conviction that energy conservation has got a restricting character (“energy conservation will restrict my freedom”, “Energy conservation means to live less comfortably”) which is more strongly marked in the experimental group.

Figure 4.1.16: Changes of ecological awareness of experimental group and control group tenants
(n=25-28 in exp. group and 25-29 in control group due to missing values[13]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)

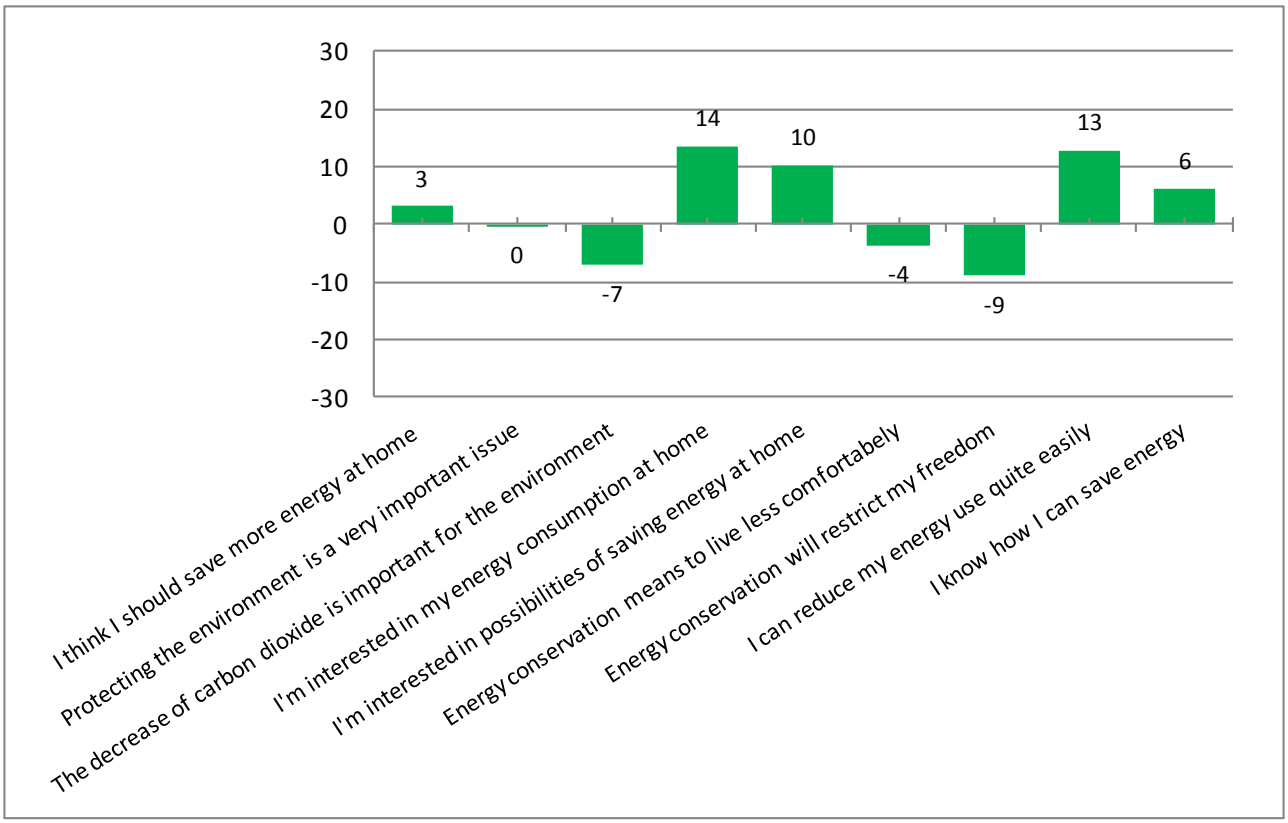


Furthermore figure 4.1.17 shows that these trends of both group result in some differences between experimental and control group at the final stage that confirm the influence of the tenant portal. Again the ecological awareness directed to the personal situation of tenants is higher in the experimental group than in the control group. This is especially true for the interest of tenants in their energy consumption and possibilities of saving energy where percentage differences go up to 14 points. Also the knowledge about how to save energy and the conviction that appropriate actions can be done quite easily are higher in the experimental group. Moreover experimental tenants more seldom feel that saving energy implies restrictions in comfort and freedom.

However, in the experimental group general convictions are equally or less pronounced than in the control group. But as the differences for “I think I should save energy” and “Protecting the environment is a very important issue” had been larger to the disadvantage of the experimental group this can be also interpreted as positive result.

[13] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.1.17: Differences between experimental group and control group at final stage
(n=25-29 due to missings[14]; percentage point differences for answer categories “strongly agree and rather agree”)



Resulting from these analyses it becomes obvious that there is an impact of the tenant portal on great parts of ecological awareness, especially on issues related to the personal interest and knowledge of the tenants.

The following table shows, based on mean comparisons (pre-post and cross-sectional) that the development of awareness in the experimental group can even be considered as statistical significant net-effect of the tenant portal for the following awareness statements: “I'm interested in possibilities of saving energy at home”, “Energy conservation means to live less comfortably”, “Energy conservation will restrict my freedom, “I can reduce my energy use quite easily”. Although the ecological awareness of the experimental group has a statistically significant increase related to the reported statements, the cross-sectional comparison at final stage shows that the experimental group has not a statistical significant higher ecological awareness than the control group. This is due to different initial situations in both groups.

[14] Answer categories „not applicable” and “don’t know” were coded as missing.

Table 4.1.9: Pre-post and cross-sectional comparisons of ecological awareness

Statement	Experimental group			Control group			Eval. group comp. final stage[2] (mean diff.)
	baseline (mean)	final (mean)	pre-post comp.[1] (mean diff.)	baseline (mean)	final (mean)	pre-post comp. (mean diff.)	
I think I should save more energy at home	1.96	1.52	0.44	1.37	1.56	-0.19	0.16
Protecting the environment is a very important issue	1.48	1.52	0.44	1.28	1.48	-0.21	-0.02
The decrease of carbon dioxide is important for the environment	1.50	1.85	-0.04	1.39	1.71	-.32	-0.11
I'm interested in my energy consumption at home	1.44	1.19	-0.35	1.14	1.48	-0.35	0.30
I'm interested in possibilities of saving energy at home	1.48	1.19	**0.30***	1.46	1.39	0.07	0.24
Energy conservation means to live less comfortably	3.71	2.71	**1.00***	2.83	2.67	1.67	-0.07
Energy conservation will restrict my freedom	4.11	2.79	**1.32***	3.33	2.96	0.37	-0.03
I can reduce my energy use quite easily	2.80	1.85	**0.95***	2.22	2.56	-0.33	0.55
I know how I can save energy	1.95	1.76	0.12	1.71	1.71	0.00	0.06

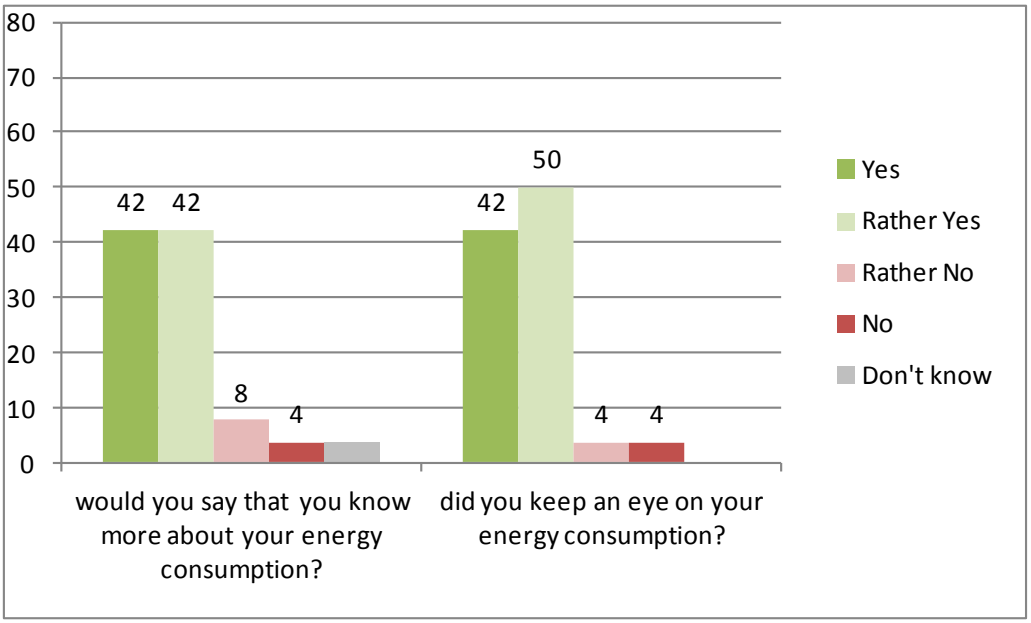
[1] A positive value means a trend towards pro-ecological awareness with exception of the last statements: “Energy conservation means to live less comfortably”, “Energy conservation will restrict my freedom”.

[2] A positive value means a desired trend which is described by the fact that the experimental group shows a better ecological behaviour than the control group (with exception of the last statement). The mean differences are calculated with SPSS statistic tool and may base on slightly different means than reported in this table due to missing values in baseline or final stage.

* The difference is statistically significant at $p<0.05$.

The positive results are confirmed by the retrospective view of the 26 final survey respondents who actively used the portal. 42% of these respondents report that they now know more about their energy consumption and that they keep an eye on it. Up to a half of them rather agree to these statements. Only one person clearly denies the statements. This also shows a positive influence of the tenant portal.

Figure 4.1.18: Knowledge and relevance of energy saving issues resulting from RUAS use
(n=26; percentages)



Question: Thinking of the provided tenant portal…
- would you say that you know more about your energy consumption?
- did you keep an eye on your energy consumption?
Answer categories: “Yes”, “Rather yes”, “No”, “Don*t know”.

Impact on ecological behaviour

For identifying the impact of RUAS on ecological behaviour the tenants were asked how they act in their everyday life. Therefore they were asked to indicate how much they agree to several statements concerning their ecological behaviour.

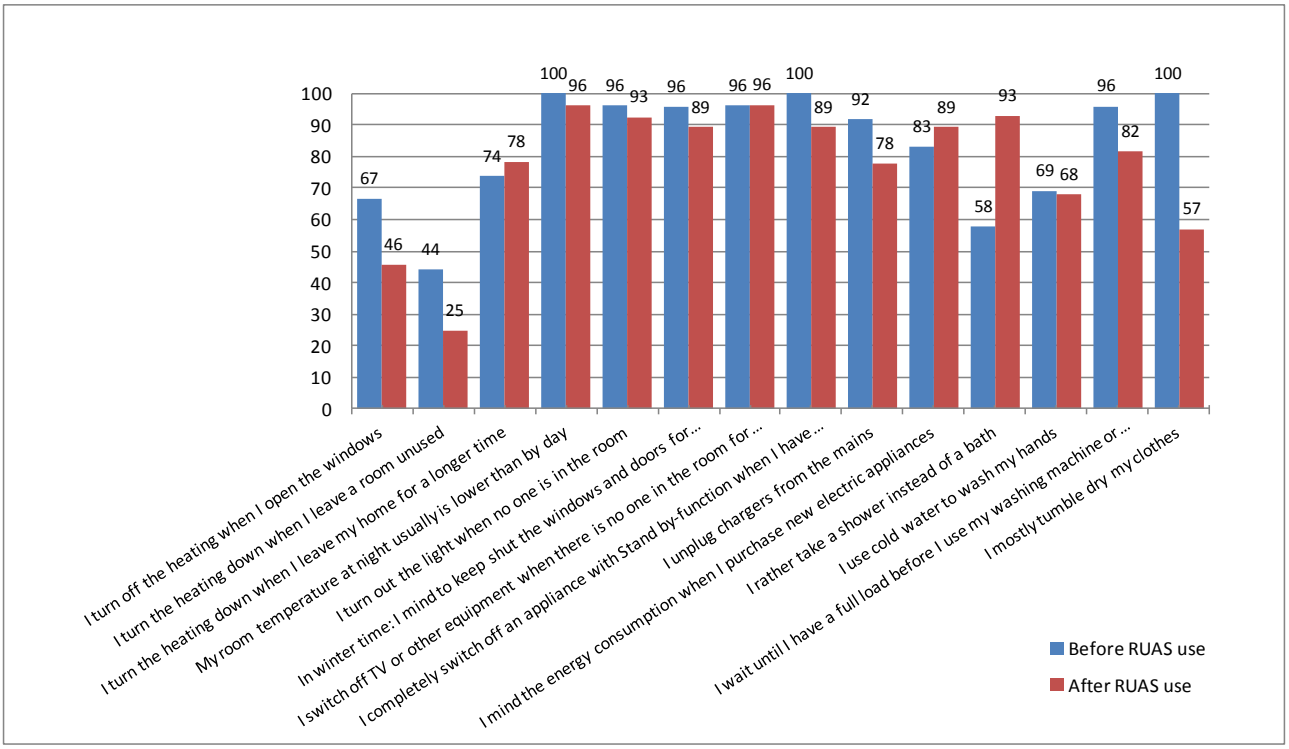
The following figure shows the percentage of the answer categories “strongly agree” and “rather agree” before and after the portal was offered to the tenants.

It becomes obvious that already before offering the services, the tenants mostly were acting in a pro-ecological manner. This is especially true for statements related to electricity consumption as turning out lights, switching off appliances and related to heat energy such as ventilation behaviour or lowering the room temperature at night. The percentages of these statements mostly decrease a little bit after the RUAS use, but this is not too much striking, because of the high percentages that nearly or fully were not able to be exceeded (such as 100% for “My room temperature at night usually is lower than by day” or “I completely switch off an appliance with Stand by-function”).

The decrease in the percentages of the heating behaviour can be explained by the strong range of sample sizes at the baseline and the final survey (due to missing values). So, the comparison of percentages provides not reliable results. The same is true for tenants that tumble dry their clothes. Here the sample sizes are additionally very low and vary between four and seven as many tenants do not own a dryer.

More robust results can be observed for the statements about purchasing new appliances and statements related to water consumption. The percentages of tenants who mind the energy consumption when purchasing new appliances rise from 83 to 89% after the RUAS use. An even better development can be observed for tenants taking a shower instead of a bath (from 58% to 93%). On the other hand, no positive trend can be found for the use of cold water to wash hands or using only full loaded washing machines.

Figure 4.1.19: Ecological behaviour of experimental group tenants before and after the use of RUAS
(n=4-28 due to missings[15]; percentages for answer categories “strongly agree and rather agree”)



Survey Question: There are different ways people act in their everyday life. To what extent do you agree or disagree with the following statements?
Answer categories: “strongly agree”, “rather agree”, “neither agree nor disagree”, “rather disagree”, “strongly disagree”, “Don’t know”; “not applicable”

Despite the mainly comparable trends for experimental and control group (see following figure), striking differences can be found for some statements. While the experimental group shows positive trends related to the statements “I turn the heating down when I leave my home for a longer time” and “I mind the energy consumption when I purchase new appliances” the control group tenants have worsened their behaviour. In addition to that tenants of the experimental group less often tumble dry their clothes than before the service use whereas control group tenants show no change.

There is one aspect with negative trends in both groups, but tenants of the experimental group show smaller percentage changes than the control group (switching off appliances with Stand by-function). In these cases the RUAS use could have helped to reduce a general negative trend.[16]

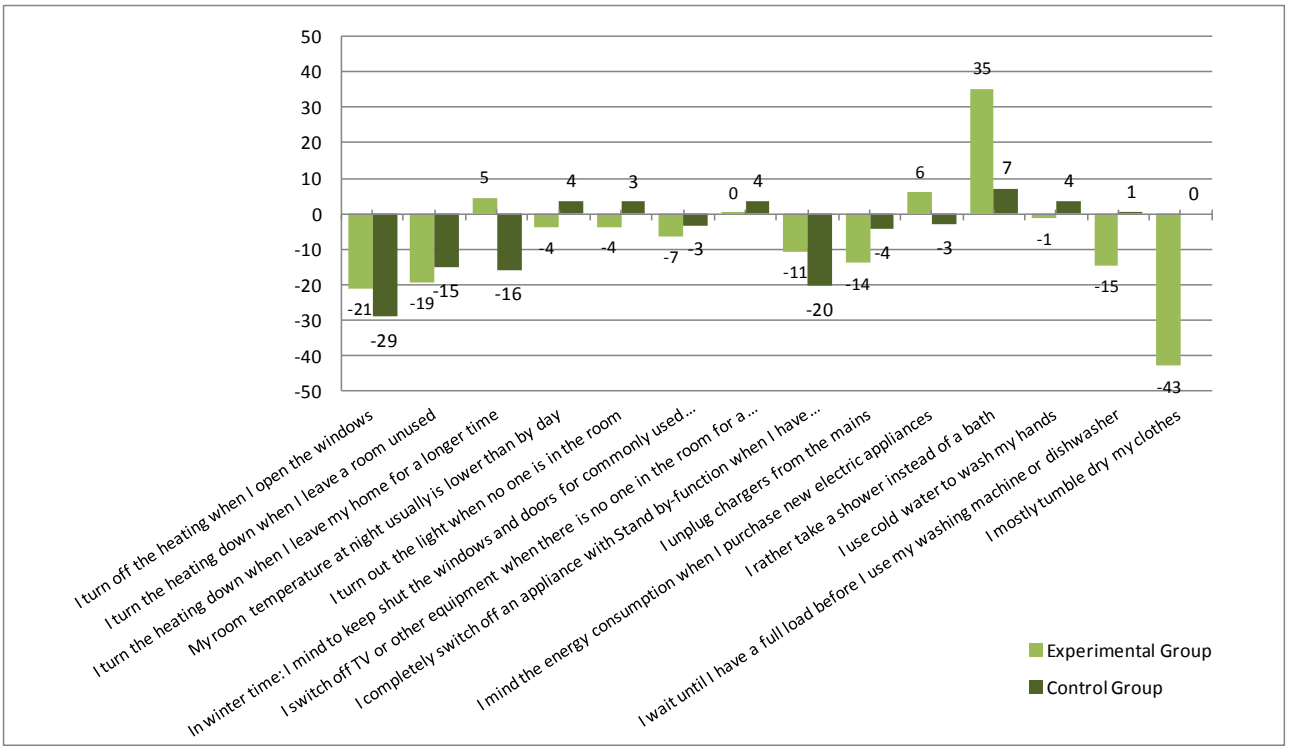
But the strongest effect can be found for tenants taking a shower instead of a bath where the experimental group shows a very clear positive trend whereas the percentage change for the control group is much smaller.

In total, the pre-post comparisons show different results for the ecological behaviour. This is partly due to high proportions of tenants with optimally ecological behaviour already at the baseline stage and highly varying sample sizes related to some statements. However, many results suggest a considerable impact of the RUAS services.

[15] Answer categories „not applicable” and “don’t know” were coded as missing.

[16] The same is true for the two statements about heating behaviour. But due to the great ranges of missing values the results should not be overestimated.

Figure 4.1.20: Changes of ecological behaviour of experimental group and control group tenants (n=4-28 in exp. group and 5-29 in control group due to missing values[17]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)



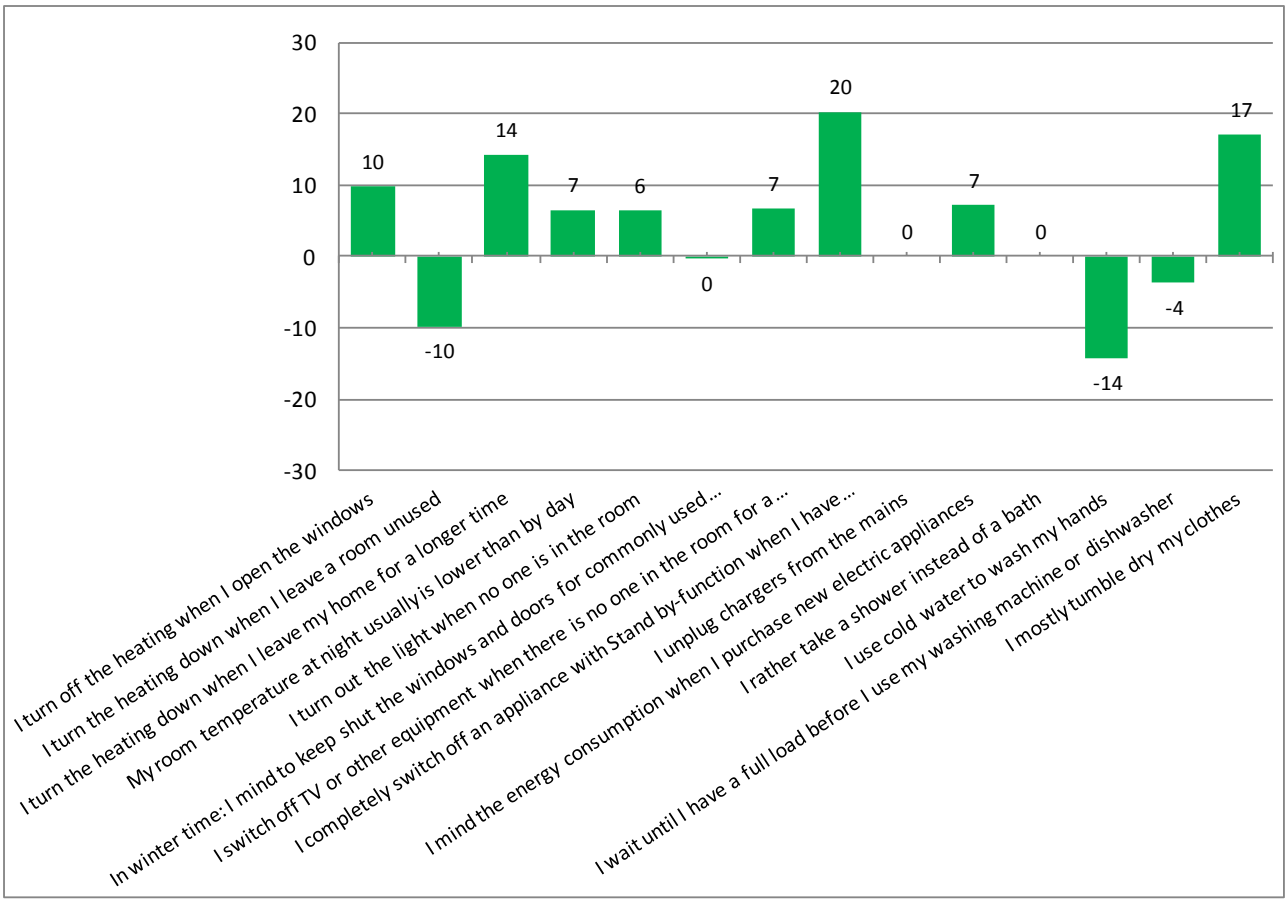
The trends reported above result in the following behaviour patterns of the experimental group and the control group at the final stage. As figure 4.1.21 shows, the tenants of the experimental group behave more often in a pro-ecological manner than tenants of the control group do. This affects eight from 14 statements. The greatest differences can be found for turning the heating down when leaving the home for a longer time and switching off an appliance with Stand by-function after using it. For the last statement the proportion of tenants with a pro-ecological behaviour is 20%-points higher in the experimental group than in the control group. The same positive effects can be found for statements covering all resources and the related behaviour. There are only a few kinds of behaviour where the control groups’ behaviour is more often appropriate than in the experimental group such as for turning the heating down when leaving a room unused, using cold water for washing hands and using only a full loaded dishwasher or washing machine.

Overall, it can be noted that the RUAS service for many statements lead to an improved ecological behaviour of the experimental group or to keep their already appropriate behaviour up which is more often appropriate than for the control group or the services contribute to reduce differences between both groups that are on disadvantage of the experimental group. These results can be interpreted as strong advices for a net-impact of the RUAS services even if it the statistical significance of the differences cannot be verified. [18]

[17] Answer categories „not applicable” and “don’t know” were coded as missing.

[18] Pre-Post comparisons based on means are not useful as sample sizes are too low.

Figure 4.1.21: Differences between experimental group and control group at final stage
(n=7-29 due to missings[19]; percentage point differences for answer categories "strongly agree and rather agree")



Ventilation behaviour

The ventilation behaviour is a special issue concerning heat energy consumption as many people waste a lot of heat energy due to inconvenient ventilation behaviour. That's why some additional questions about this have been asked to the tenants.

Figures 4.1.22 and 4.1.23 show the ventilation behaviour of both groups at final stage on the basis of respondents that have at least participated in the final survey.[20]

Big parts of both comparison groups are acting in a pro ecological way. However, it is remarkable that the tenants of the experimental group mostly leave windows ajar at times, which is the second best solution only, while tenants of the control group open their windows widely at times and that's why more often act in the best manner. Nevertheless, in kitchens and bathrooms where normally the highest rates of humidity can be found, the proportions of experimental group tenants who also open the windows widely at times is higher than in other rooms.

The tenants also have been asked whether they are leaving windows ajar over a period of at least 1 hour a day which is not the case for the majority of tenants. The percentage in the control group is 72% and exceeds the one in the experimental group (64%). So it can be noticed that ventilation behaviour is adequately for large parts in both groups.

[19] Answer categories „not applicable" and "don't know" were coded as missing.

[20] A pre-post comparison is not possible as the question was modified in final stage.

Figure 4.1.22: Ventilation behaviour of exp. group tenants in winter time (final stage)
(n=17-29 due to missings[21]; percentage)

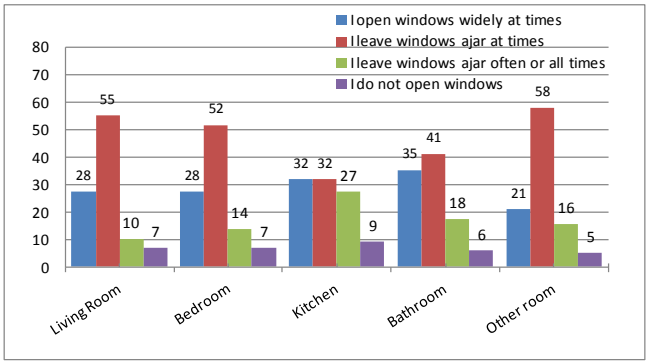
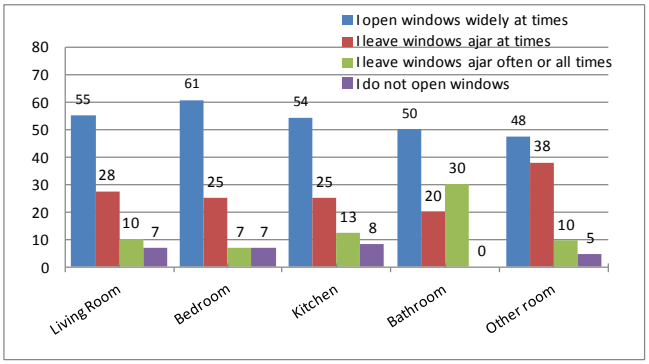


Figure 4.1.23: Ventilation behaviour of control group tenants in winter time (final stage)
(n=20-29 due to missings[22]; percentage)



Room temperature and use of air conditioning

The room temperature in winter time is one further important factor of the heat energy consumption. That's why the tenants have been asked for telling the room temperature in much used rooms and in little used ore unused rooms.

The comparison of control group and experimental group at the final stage reveals rather high temperatures for both groups, especially in little used/unused rooms.[23] In much used rooms the temperature is about 22 degree in both groups, in little used or unused rooms it is about 21 degree in both groups.

Although this represents rather high room temperatures (normally a room temperature of 20 degrees is recommended for not wasting energy, but living comfortably), it has to be taken into account that the subjective perception of which temperature is comfortable can vary strongly among individuals. In addition to that, older people and babies have got a higher demand of high indoor temperatures. In the available sample the mean age of the experimental group tenants is slightly higher (57 years) than in the control group (50 years), a correlation with the room temperature cannot be verified.

It is also remarkable that 61% of the tenants of the experimental group did not know their room temperatures at baseline stage whereas this proportion decreases in final stage to 25% related to much used rooms, and 36% related to little used or unused rooms. This means that tenants were not aware of the relevance of room temperatures prior the portal use, but have now started to keep an eye on it. This can be seen as a step into the right direction.

In summer time the room temperatures can indicate if energy is wasted when an air conditioning is available. This is true for 36 tenants of both groups. The room temperatures in summer reveal no differences between experimental and control group. At final stage the mean temperature is at 26 degrees for much used rooms and 28 degrees for little or unused rooms. As these temperatures are already high temperatures, an excessive use of the air conditioning system cannot be stated for both groups. The majority of the experimental group states to use the air conditioning 1-3 hours a day (71%), 12% use it less than 1 hour a day and 18% 4-8 hours a day. Nobody of the experimental group uses it more than 8 hours a day.

In the control group there are greater proportions using the air conditioning 4-8 hours a day (25%) or more than 8 hours (20%), although the majority also states to use it 1-3 hours a day. Only 10%

[21] Answer category „not applicable/no window in room" was coded as missing.

[22] Answer category „not applicable/no window in room" was coded as missing.

[23] Due to the small sample sizes a pre-post comparison is not useful.

(2 persons) use the air conditioning less than 1 hour a day. In total, it can be noted a slightly lower duration of air conditioning use in the experimental group. As this difference not yet occurred during baseline stage and moreover tenants of the control group are absent from their home for longer time periods than tenants of the experimental group (see Table: 4.1.8) this can be interpreted as an effect from the RUAS service.

Retrospective and prospective behaviour

When asking directly whether the portal users changed their behaviour due to the portal use or not, there are 12 percent stating “yes”. 54% don’t think that they changed their behaviour and 35% are undecided. This shows that everyday behaviour is following routines that cannot be changed in a short time period and people are not always aware of it. But even if there seems to be no globally changed behaviour, the analyses could show that for single topics there are positive trends obvious (mainly) caused by the tenant portal.

In addition to that more than two thirds (69%) of the portal users intend to conserve heat energy next winter and 77% intend to conserve electricity and/or water in future. This means that the portal users are ready to work on their behaviour in order to reduce their energy consumption.

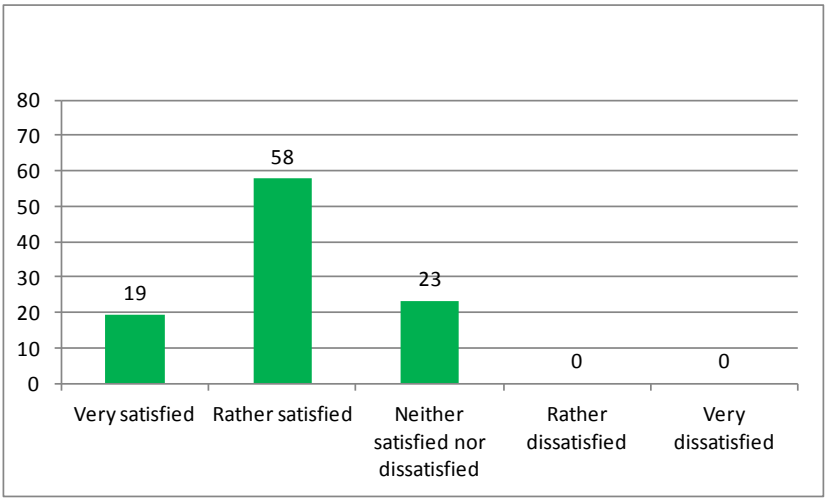
Overall, it can be stated, that the RUAS services show effects on large parts of the tenants’ ecological behaviour, but these effects cannot yet be found in relation to every resource. This and the relatively small proportions of tenants believing to have changed their behaviour show that changing ones habits needs a longer time period. However, the experimental group behaves more often in a pro ecological manner related to several aspects than the control group does. Even if these results mainly are not statistically significant and therefore results could also be caused by chance, they can be interpreted as net-impact caused by the RUAS services.

Satisfaction with tenant portal

To achieve a high satisfaction with the tenant portal was an additional objective of the BECA project. The following analyses show the opinions and experiences of all active portal users.

In general, there is a high general satisfaction with the tenant portal. Nearly all portal users are very or rather satisfied (n=20); only six persons are neither satisfied nor dissatisfied. However, the largest percentage of users is rather satisfied which shows that there might be some aspects (what will be examined further down) that could still be improved.

Figure 4.1.24: General satisfaction with tenant portal
(n=26; percentage)

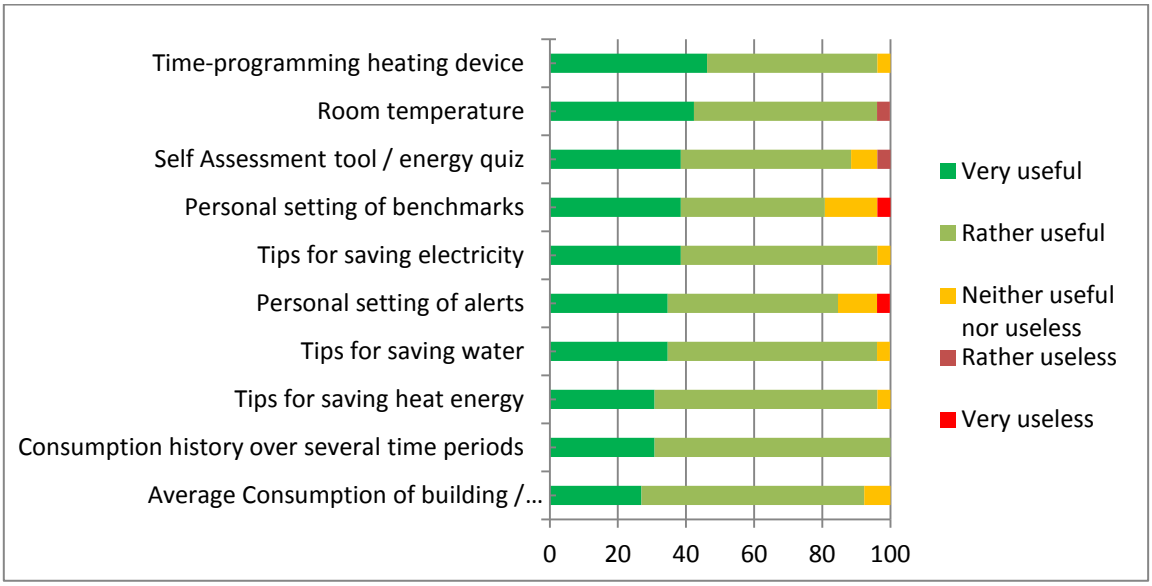


Question: How satisfied are you with the services of the tenant portal in general?

Taking a closer look at different aspects of the tenant portal, it can be found that the portal users judge the information presented as useful. Focussing on the rates of the answer category “very useful” the time-programming heating device (46%) and the presentation of the room temperature (42%) are the most important features followed by the self assessment tool, personal setting of benchmarks and tips for saving electricity that are ranked together in third position with 39% each.

More than two thirds of the users consider the personal setting of alerts and tips for saving water as very useful features (each 35%). Although showing the consumption history over several time periods and the average consumption of the building achieve a little bit lower percentages, many tenants consider these aspects as rather useful. This shows that all features are helpful for the tenants and meet their interests and requirements.

Figure 4.1.25: Usefulness of information presented in the tenant portal
(n=19; percentage)

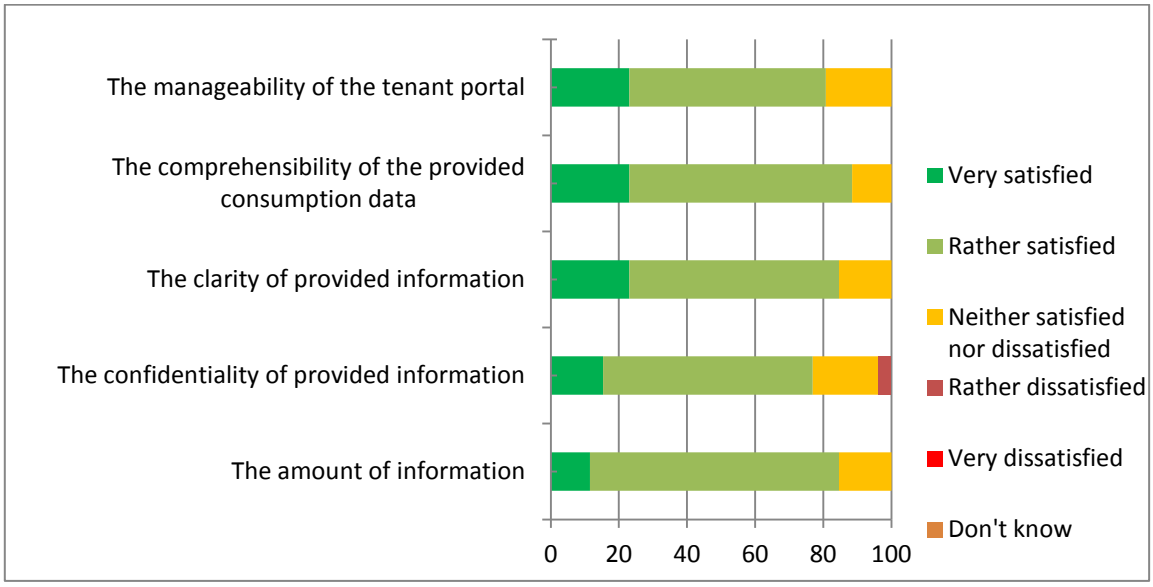


Focussing on further aspects dealing with the handling of the portal and its information, the positive picture is confirmed. The majority of users are very or rather satisfied with the manageability of the portal and with comprehensibility, clarity, amount and confidentiality of the provided information. Nevertheless, the percentages of very satisfied users are somewhat lower: The highest percentage

is very satisfied with the manageability of the portal, the comprehensibility of the consumption data and the clarity of the information (23%, 6 out of 26 users). The confidentiality and the amount of information are stated as very satisfying from 15% and 12% of active users. The confidentiality of provided information is also the only feature that is considered as rather dissatisfying (1 person). The other features receive no negative judgments at all.

No one of the active users is reporting on any problems during the portal use.

Figure 4.1.26: Satisfaction with handling of the tenant portal
(n=26; percentage)



Prospective portal use and willingness to pay

The high satisfaction of the portal users can be underlined by their intention to use the tenant portal frequently in future which is stated by almost all of the 26 users (only 1 person doesn't want to use the portal in future). Nearly half of them are so much committed to the service that they consider purchasing an energy monitoring device that is comparable to the tenant portal (48%). Those 12 users are willing to pay 200 up to 1.000 Serbian Dinar per month. That equates to an average of 4 Euro (mean) resp. 3.50 Euro (median).

Amount per month that users are willing to pay	Serbian Dinar	EUR
Minimum	200	1.75
Maximum	1000	8.74
Median	400	3.50
Mean	458	4.00

Overall, the active users are very satisfied with the tenant portal. Some features could be slightly improved from the respondent's point of view (e.g. manageability of portal information). The intention to use the portal in future and the willingness of many tenants to pay for a similar portal shows the great success of the RUAS provided.

4.1.4 Results of combined analysis

The combined analysis of survey data and consumption data helps on a better understanding if and how energy consumption is related to the ecological awareness and personal interests of the tenants or their everyday behaviour. This helps to understand the processes of how energy savings can be achieved when taking into account the perspective of the tenants. This might support the identification of triggers that have an effect on energy consumption and that can be influenced by tenant services such as the RUAS operated in the BECA project.

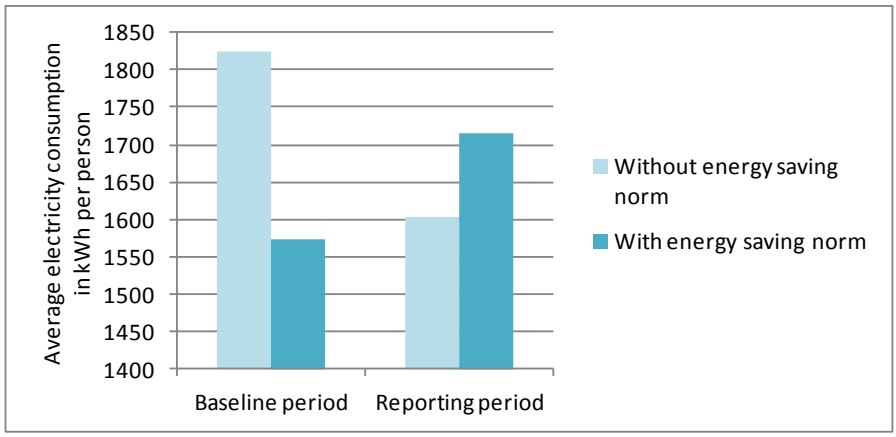
As consumption data in Belgrade for heat energy and water consumption are available on an apportioned, but building-wise level only, the following analyses concentrate on electricity consumption.

Subjective energy saving norm and electricity consumption

Information about the subjective energy saving norm was gathered with an item related to the ecological awareness of tenants (“I think I should save more energy at home”). This norm can be treated as the main driver of the individual willingness to save energy.

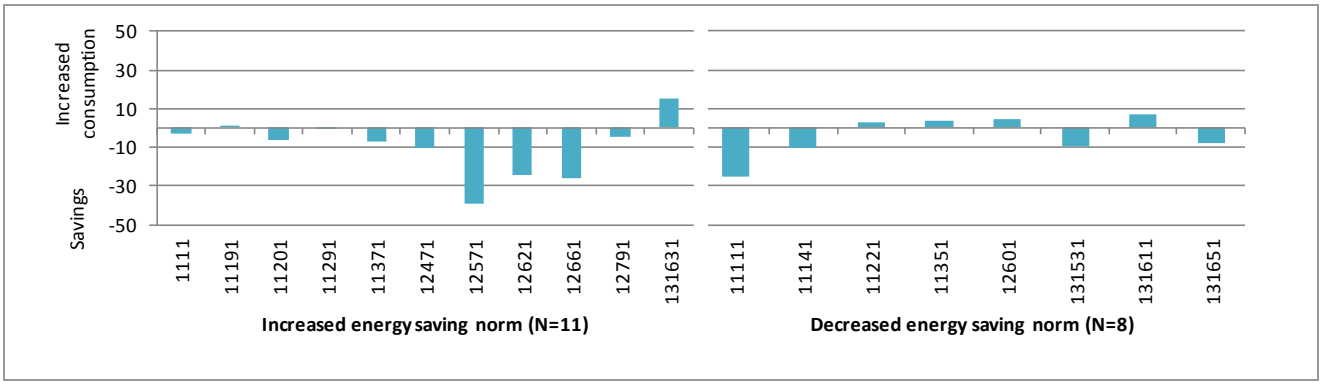
As the following figure shows, tenants who reported a strong energy saving norm in the baseline survey (“I strongly agree”) consume less energy than tenants without that strong norm. Related to the energy consumption in the reporting period the opposite is the case.

Figure 4.1.27: Electricity consumption of respondents with and without strong energy saving norm



Even if the positive link between energy saving norm and energy consumption is obvious in the baseline period only, it is of interest whether tenants saved more energy when their energy saving norm increased during baseline and final stage or not, compared to those tenants with a decreased or unmodified energy saving norm. As figure 4.1.28 shows, tenants with an increased energy saving norm achieved more often electricity savings than tenants with a decreased energy saving norm, and they show somewhat higher savings. The average savings of tenants with an increased energy saving norm were -9.1%, whereas tenants with a decreased energy saving norm achieved smaller savings of -4.2%. The finding that tenants with a decreased energy saving norm also achieved savings can be explained by their rather high compliance with the energy saving norm. This means that the majority of these tenants rather agreed that they should save more energy at home.

Figure 4.1.28: Percentage change in electricity consumption for tenants with increased and decreased energy saving norm



Tenants with an unchanged energy saving norm in both survey stages did not achieve any savings, but showed an consumption increase of 16% on average. All these tenants had a constantly high-level energy saving norm which means that all tenants of this sub-group strongly or rather agreed to that item (91% strongly agree; 9% rather agree). Therefore for those tenants can be stated that the subjective energy saving norm do not serve as a trigger anymore in order to save even more energy. This is confirmed by their already lower electricity consumption during the baseline period (mean: 1202 kWh/person) compared to those tenants with an increased energy saving norm (mean: 2165 kWh/person) or with a decreased energy saving norm (2066 kWh/person).

This result shows that the effort of influencing the energy saving norm is a useful purpose of the RUAS services, because it can effectively help to save energy. However, as shown above the impact depends on the initial situation and the potential remaining. The success of the Belgrade RUAS with respect to the energy saving norm and further aspects of ecological awareness was also shown in the survey analysis (see section 4.1.3).

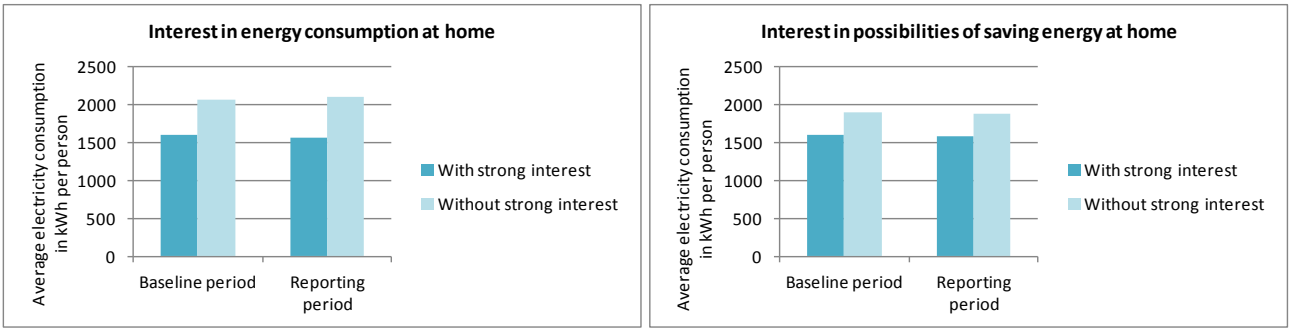
The influence of the energy saving norm seems to be additionally effected by the group status of the tenants. So a positive influence on tenants of the experimental group with constantly positive or increased energy saving norm became obvious who achieved saving of -8% and -12%, whereas the control group showed an increased consumption in both sub-groups (29%; 16%). Even if the sample sizes are very low (e.g. in the control group only 1 tenant has an increased energy saving norm) it can be concluded that the energy saving norm per se seems to be not sufficiently enough to achieve savings, but it should be combined with further aspects such as further information about possibilities how to save energy as it is given in the RUAS. This result confirms the positive impact of the RUAS at the Belgrade pilot.

Personal interest in energy saving issues and electricity consumption

A further strong driver for the willingness to conserve energy consists in the personal interest of tenants in energy saving issues at home. In the survey two details are available: the interest in the own energy consumption at home and the interest in the possibilities to save energy at home.

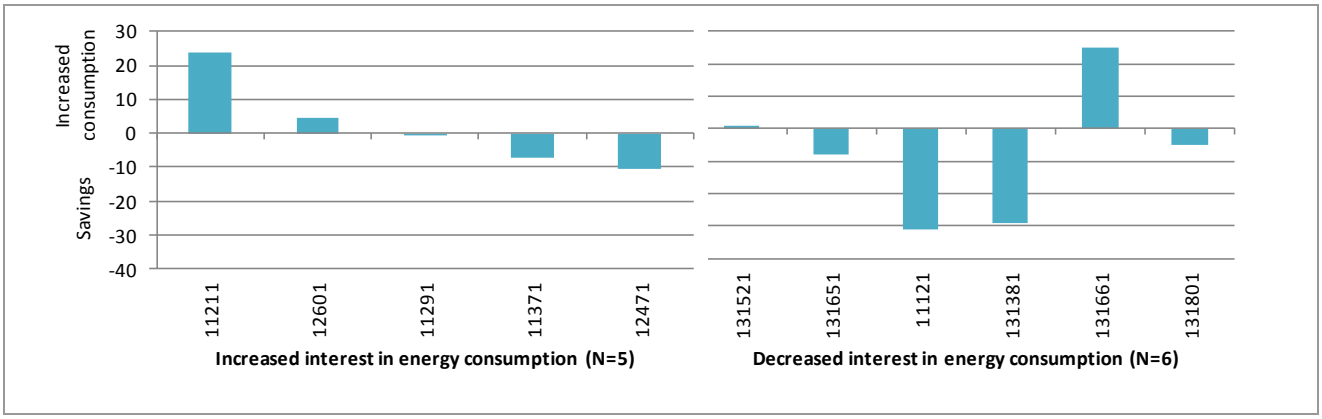
When considering tenants who reported on strong interest in energy saving issues in the baseline survey, it becomes obviously that the personal interest is directly linked to the energy consumption. So figure 4.1.29 shows lower average electricity consumptions related to baseline period and reporting period for tenants who have strong interest than for persons without such a strong interest. This is applicable for both the interest in the own energy consumption at home and the interest in the possibilities of saving energy.

Figure 4.1.29: Electricity consumption of respondents with and without strong personal interest in energy saving issues at home



In a further step it has been examined how a change of interest is related to changes in consumption. At first sight the change of interest in the own energy consumption at home does not reveal the expected results: Whereas tenants with an increased interest have an increased consumption of 1.9%, tenants with a decreased interest have savings of -8.0% in average. But as figure 4.1.30 shows, this result can be partly explained by two tenants with a decreased interest who show very high savings. In contrast, the percentage change in electricity consumption of tenants with increased interest is generally small. Given the fact that the sample sizes are very small, this carries weight when calculating the averages. A further explanation could be that the changes of interest are very small. In most cases tenants who reported a strong interest at the baseline stage now turned into rather strong interest at the final stage and the other way round. That's why other aspects might have influenced the changes in consumption.

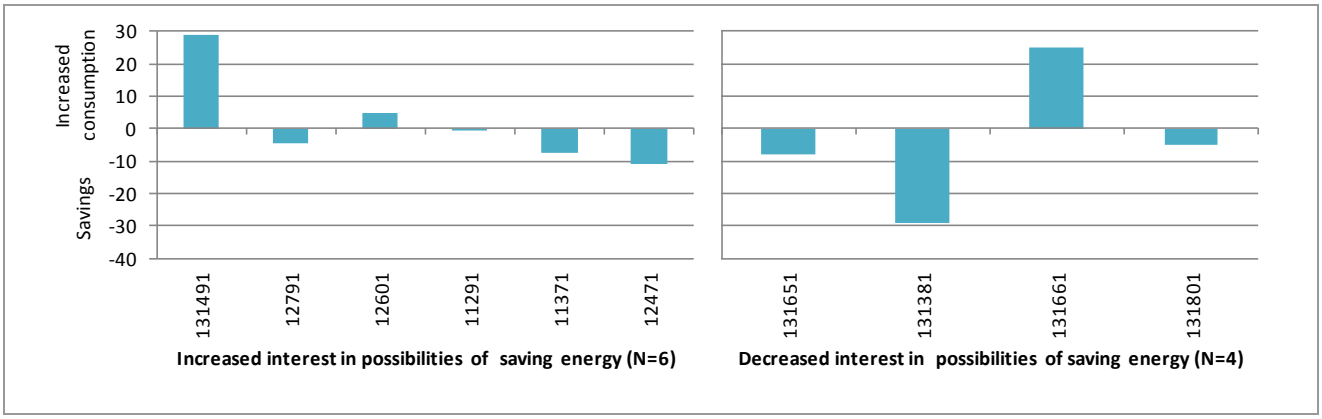
Figure 4.1.30: Percentage change in electricity consumption for tenants with increased and decreased interest in energy consumption at home



With respect to the change of interest in the possibilities of saving energy at home, no clear trend can be found. As before, the analysis is based on a very small number of cases and shows a slightly increased average consumption of tenants with increased interest (1.7%), but savings of tenants with decreased interest (-4.3%). However, it becomes again obvious that the increased consumption of tenants with increased interest is due to one outlier who shows an increased consumption of nearly 30%. One explanation could be that this outlier had a rather low consumption during the baseline period and therefore the potential for achieving savings is low. In addition to that, this tenant belongs to the control group and therefore received no further support to achieve savings. The remaining tenants with increased interest belong to the experimental group and most of them achieved some savings. However, tenants with a decreased interest mostly show savings too. These results suggest that there are different factors than the interest in energy saving issues at home that may have influence on the energy consumption. Nevertheless,

this result should not be over-interpreted as the sample sizes are very low and may give a biased impression.

Figure 4.1.31: Percentage change in electricity consumption for tenants with increased and decreased interest in possibilities of saving energy at home



Everyday ecological behaviour and electricity consumption

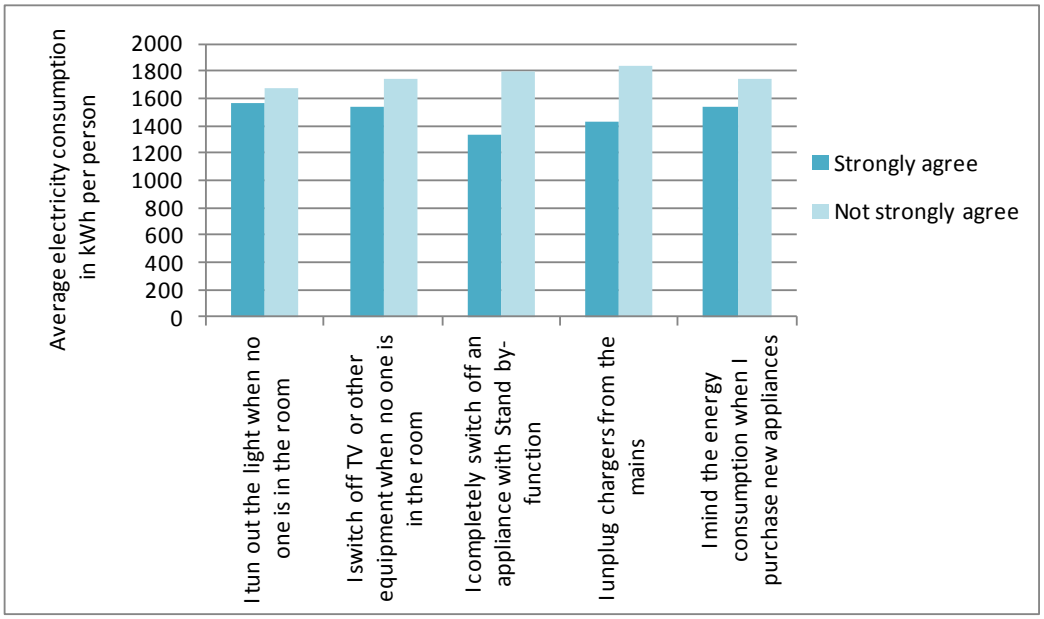
The relation between the actual ecological behaviour and the consumed energy is another important issue to examine. It can be assumed that the relation between behaviour and energy consumption is more direct than it is between ecological awareness resp. energy saving norm and energy consumption. Therefore the ecological behaviour reported at the final survey was analysed with regard to the measured electricity consumption during the reporting period.

Survey information is available for the following activities related to electricity consumption: turning out the light when there is no one in the room; switching off TV or other equipment when there is no one in the room; completely switching off appliances with stand by-function; unplugging chargers from the mains; mind the energy consumption when purchasing new appliances.

The following figure shows related to all above mentioned activities that tenants who strongly agree to the behavioural items have somewhat lower electricity consumption during the reporting period than tenants who do not strongly agree.[24] This suggests that tenants who strongly agree to the items always or nearly always act in the recommended manner which can lead to reduced energy consumption.

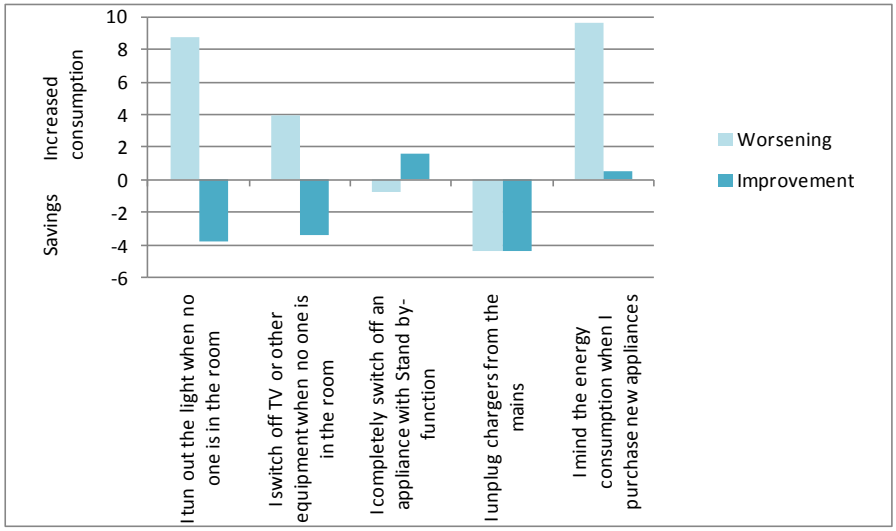
[24] This includes the following answers: I rather agree, I neither agree nor disagree, I rather disagree, I strongly disagree.

Figure 4.1.32: Electricity consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



When analysing the percentage change in electricity consumption related to the change in ecological behaviour, then different results become obvious. Tenants with improved behaviour with respect to turning out the light and switching off TV achieved average savings of -3.8% and -3.4%, whereas tenants with worsened behaviour have a consumption increase of 8.7% and 4.0%. For changes in completely switching off appliances with stand by-function no meaningful changes in electricity consumption can be found. Related to the unplugging of chargers both groups of tenants achieved saving of -4.4% in each case. In contrast, related to keeping the electricity consumption in mind when purchasing new appliances both groups of tenants show an increased consumption of 9.6% (worsened behaviour) resp. 0.5%.

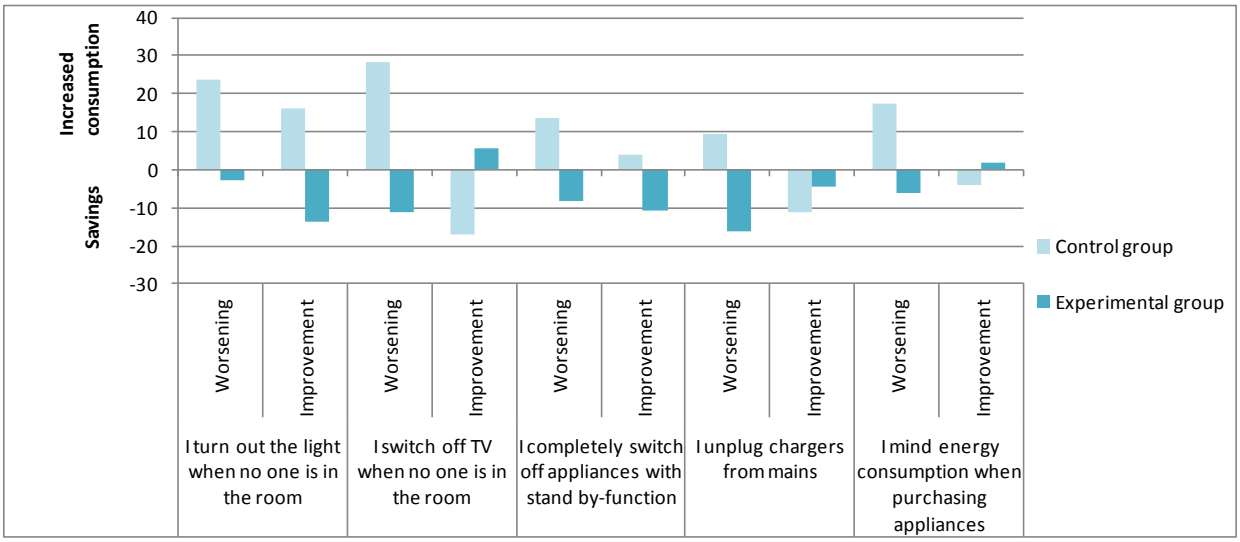
Figure 4.1.33: Percentage change in electricity consumption for tenants with worsened and improved ecological behaviour



These results suggest that not all activities asked for contribute in the same way and level to a change in energy consumption and / or that further factors are more relevant for savings or

increased consumptions. One other factor could exist in the evaluation group the tenants belong to. Figure 4.1.34 shows the results especially related to the evaluation group. Although there is a very low number of cases for single subgroups (see N mentioned in the figure), there are some interesting findings. So tenants with worsened behaviour have achieved savings if they belong to the experimental group, but they have increased consumption when they belong to the control group. This suggests that tenants of the experimental group seem to be positively influenced by the RUAS even if they have worsened their behaviour related to the activity given. Among the respondents with improved behaviour, those tenants belonging to the experimental group also show savings for three out of five activities. This suggests that the influence of the experimental group seem to interfere with the influence of the behaviour. However, these results should be treated carefully due to the low sample sizes. In addition to that, it has to be taken into account that – especially for electricity consumption – it is rather difficult to achieve high savings only by adapting the behaviour. For example the purchase of a further appliance can lead to an increased consumption although the tenant did change his behaviour to a pro-ecological manner. In addition to that, especially the replacement of high-consuming large appliances by energy efficient ones would have a significant influence on the electricity consumption. That was not topic of the study.

Figure 4.1.34: Percentage change in electricity consumption for tenants with worsened and improved ecological behaviour by evaluation group

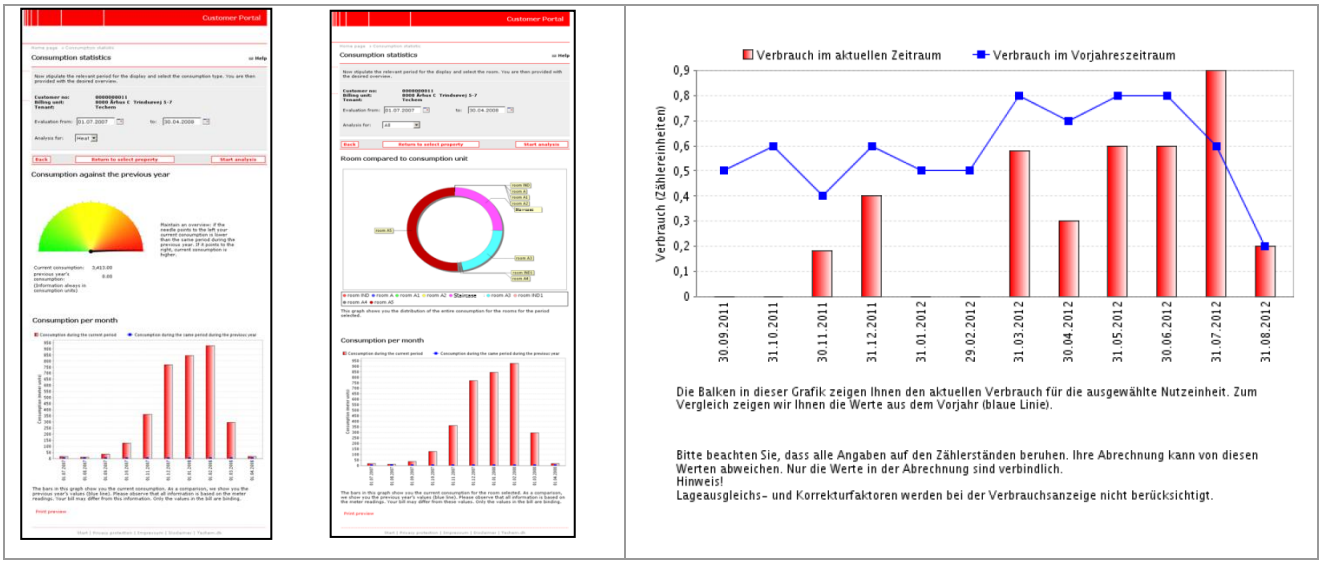


4.2 Darmstadt

4.2.1 Background information

Darmstadt implemented a RUAS as well as a RMS. The RUAS tenant portal provides feedback on the current heat energy, hot and cold water consumption (daily, weekly, monthly or quarterly) in combination with historical information of the previous year and average consumption values of all dwellings in the building as a benchmark. The consumption is also shown for different rooms. The relevant graphs are shown directly after the tenant's log-in to the web portal with their personalised account, which is organised via an email-authentication process.

Figure 4.2.1: Screen shots of RUAS tenant portal (left) and RMS professional portal (right)



The RMS (Techem adapterm) serves as an optimisation and monitoring instrument related to the heating system. It provides the professional staff with information about the status of the central heating system by using heating curves as well as consumption figures and by taking into account further parameters as, for example, indoor and outdoor temperatures.

In total, 675 dwellings in 45 buildings were part of the BECA project. That basic population was divided into three different setups: The *basic setup* (where smart metering equipment was installed as well) serves generally as control group for both RMS and RUAS because tenants living there could not make use of the tenant portal respectively a RMS does not exist. The *medium setup* has been equipped with the RMS, but there is no RUAS in operation. That means that this group represents an experimental group for RMS, but a control group for RUAS. The *top setup* includes a RMS as well as a RUAS and serves as all-experimental group.

Table 4.2.1: Basic population of dwellings in the three setups

Group Status	Basic Setup (15 buildings)	Medium Setup (21 buildings)	Top Setup (9 buildings)	Total
Experimental group RUAS			x	220
Experimental group RMS		x	x	409
Control group RUAS	x	x		455
Control group RMS	x			266
Dwellings with measurements	266*	189	220	675

* An additional commonly used room is not taken into account in the data analysis.

The evaluation concept includes pre-post comparisons as well as control groups. For each setup presented in the above table pre-post comparisons were possible. Comparisons of experimental and control group have been carried out as appropriate. However, due to unforeseen divergent implementation dates of the metering equipment or the services the comparison periods had to be shortened for the purpose of evaluation of heat energy consumption. The comparable observation periods which include the highest possible sample size are as follows: baseline period Dec 2011 – Feb 2012, reporting period Dec 2012 – Feb 2013. That procedure guarantees that always the most significant months of the heating period could be compared.

Related to hot water and cold water both baseline and reporting period cover 12 month in each case as planned: baseline period Nov 2011 – Oct 2012, reporting period Nov 2012 – Oct 2013.

The tenant recruitment strategy included posters for tenants explaining the project in an easily understandable way. For the top setup with the possibility of RUAS use an “energy day” was arranged where several educational and introductive materials were provided to the tenants as well as training sessions for the portal use were offered. Tenants who showed interest in the portal were visited at home and face to face introduced to the portal and its functionality (for further details see D.5.2).

Despite these efforts, the motivation of tenants for using the portal was quite low. From the 220 addressed pilot tenants with possible access to the portal, until October 2013 28 households showed their interest by asking for a password. Seven tenant households logged in at least once. According to the pilot site leader that low interest is mainly due to the tenants’ social structure in Bauverein buildings that is in general and in particular in the pilot sites implying a ratio of recipients of social subsidies above average and a general access to online services and technology below average as a result of the age structure and educational level of the tenants. These circumstances suggest a limited intrinsic interest in an online service related to energy consumption behaviour. Furthermore the procedure to acquire a password was rather complex. Tenants needed to ask for a password and send their email-address to the service provider which can be a hurdle especially for tenants with the above described social background.

That means for evaluation that additional user/non-user comparisons related to the RUAS experimental group could not be realised. Nevertheless, in general the impact resulting from the RUAS usage on tenants’ behaviour and awareness can be identified with help of a pre-post tenant survey design with control group. However, the significance of the results is limited due to the also weak response rates of the survey (see section 4.2.3).

4.2.2 Results of consumption analysis

In Darmstadt the consumption analysis was related to heat energy, hot water and cold water. All data were available dwelling-wise on a monthly basis.

Table 4.2.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	dwelling-wise
Hot water	m^3	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. Due to a change of tenancy, 116 dwellings (17%) had to be excluded from the analysis. Related to heat energy, further 210 dwellings dropped out due to the provision of inconsistent consumption data which include single monthly data as well as cumulative values for several months together. These cases could not be taken into account because it is not possible to use a regression model (as eeMeasure does) with such mixed datasets.

That means that nearly half of the dwellings remained in the analysis of heat energy consumption data. In the cases of hot and cold water more than 80% of the pilot dwellings could be analysed (see following table).

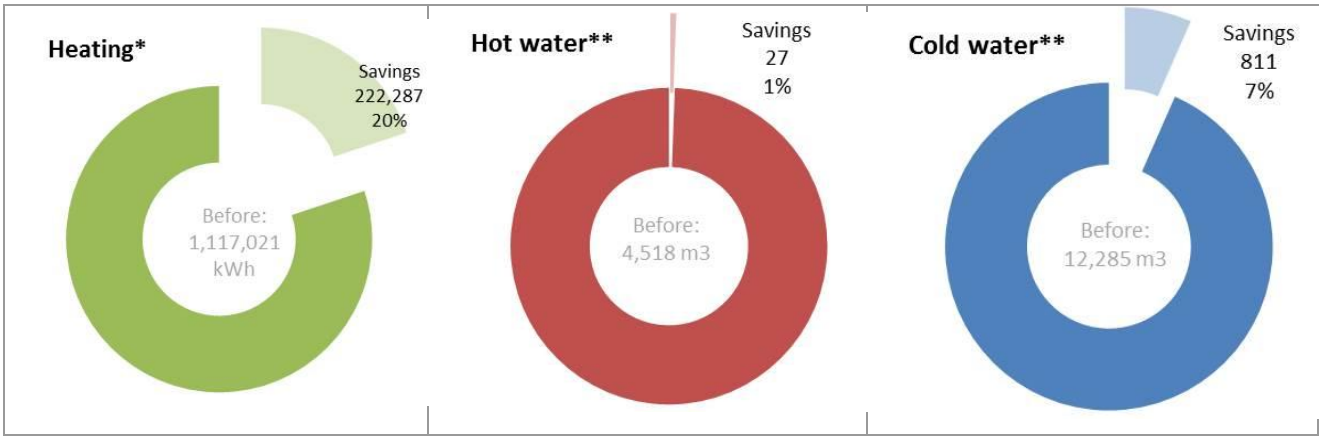
Table 4.2.3: Overview of the number of dwellings involved in the Darmstadt pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Darmstadt	45	675	Heating: 349 (RUAS: exp. 90+contr. 259; RMS: 210+139) Hot water: 557 (RUAS: exp. 188+ contr. 369) Cold water: 557 (RUAS: exp. 189+ contr. 368)	Change of tenancy (applicable for all resources): 116 (17%) Further exclusion: Heating: 210 (31%, due to mix of cumulated and monthly data) Hot water: 2 (0.3%, missing data) Cold water: 2 (0.3%, missing data)

Global results

The calculation of the global savings led to the results shown in the following figure. In the experimental dwellings in total more than 220 thousands kWh heat energy could be saved related to the above described three-month observation period within the heating period. In addition to that, the experimental tenants provided with RUAS (top setup) reduced their water consumption by 27 m^3 hot water and by 811 m^3 cold water.

Figure 4.2.2: Overview of global results of the experimental group in Darmstadt



* related to top and medium setup with RMS and partly RUAS available (n=210) related to a three-month observation period (Dec – Feb); see explanation in the background chapter above

** related to top setup with RUAS available (n=188 resp. 189)

Compared to the target setting of more than 6% up to 10% savings it becomes obvious that related to heating that target setting could be overachieved. There are several possible explanations for these – better than expected – saving results: Although heating degree data was used to correct for climatic effects, there are two other impacts which are difficult to measure, but can have a significant influence on total energy consumption. These are solar irradiance and outside wind speed. These factors change energy consumption depending mainly on the physical structure of the building and the local geographic situation.

Related to cold water the achieved savings met the expected savings. Only in the case of hot water the achieved saving remain below expectation.

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

Table 4.2.4: Overview of global CO_2- and cost savings of the experimental group in Darmstadt

Energy / resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy	0.246 kg CO_2/kWh[25]	54,683	0.098 €/ kWh	21,784
Hot water	n/a	n/a	9 €/m^3	243
Cold water	n/a	n/a	5 €/m^3	4,055
Total		**54,683**		**26,082**

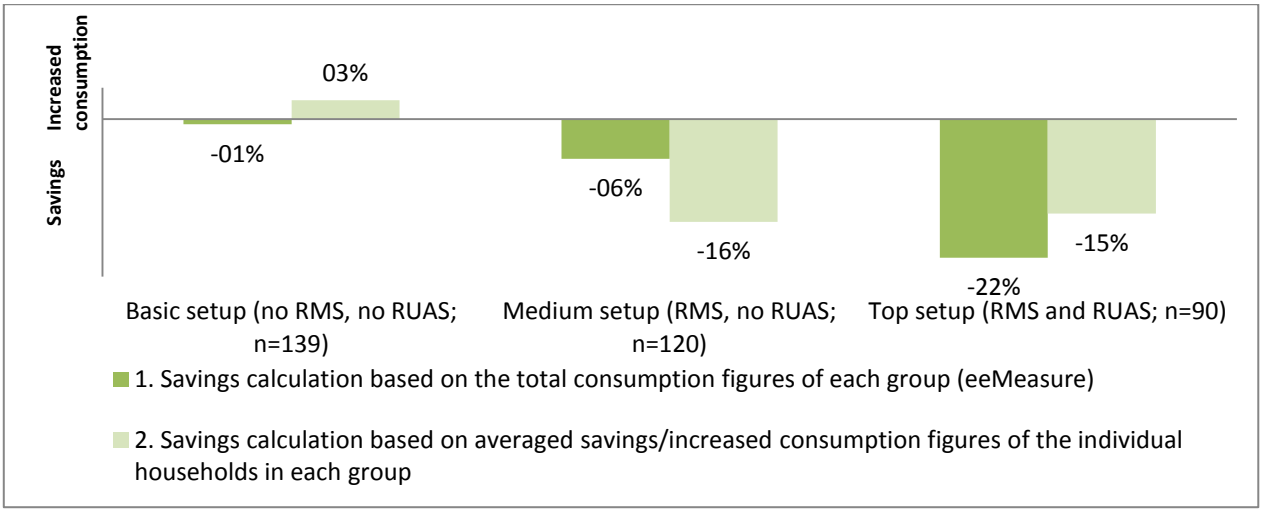
Heating

The following figure shows that the RMS has a big positive impact on heat energy reduction. Both setups with RMS available achieved significant savings compared to the control group (basic setup without any service) with more or less unchanged consumption figures. The differences in the savings presentation are again due to the divergent calculation models.

Due to the fact that the RMS principally takes effects on all dwellings together, in that case the results of the calculation approach 1 seem to be of higher explanatory power. These results suggest that also an impact of the RUAS resp. the awareness campaign (e.g. the realised "energy day") became obvious. The analysis of the impacts of tenant portal use is restricted due to the very small number of users and to the overlapping with the RMS effect. However, from the five actual users in the dataset four achieved savings with a range from 19% up to 47%. Only one user had a small consumption increase of 4.9%.

The individual saving figures used in calculation model 2 allowed the computation of a variance analysis in order to investigate in group differences. The analysis showed that both RMS setups achieved statistically significant better saving results (p<.01) compared to the control group.

Figure 4.2.3: Percentage change in heat energy consumption related to the several setups



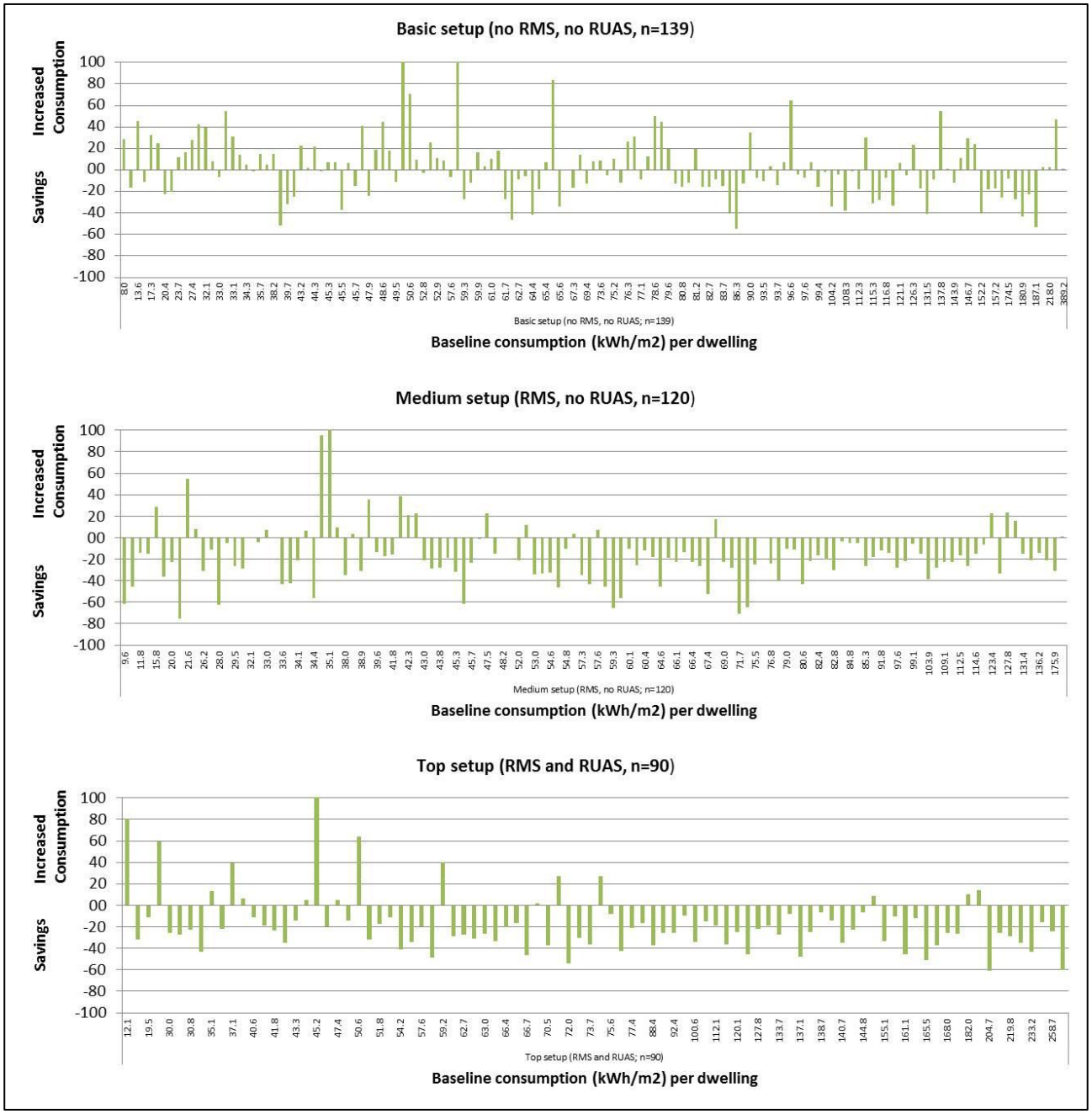
The service impacts can be underlined with the following figure. It can be seen that especially households with high baseline consumption[26] nearly totally achieved savings. That does not apply to the basic setup where a comparably bigger part of high consumers had increases.

[25] That value takes into account the different heating systems (gas, district heating) according to their share in the sample.

In 82% of the dwellings with RMS (medium and top setup) the heat energy consumption could be reduced by 26% resp. 28% on average. The remaining 18% dwellings had an increased heat energy consumption of 26% resp. 43% on average.

Compared to that, only 51% of the tenants of the control group (basic setup) had savings of 19% on average. The consumption of the other half increased by 26% on average.

Figure 4.2.4: Savings resp. increased consumption per household (in %) related to the baseline heat energy consumption (in kWh/m^2, 3-month observation period Dec-Feb) in Darmstadt

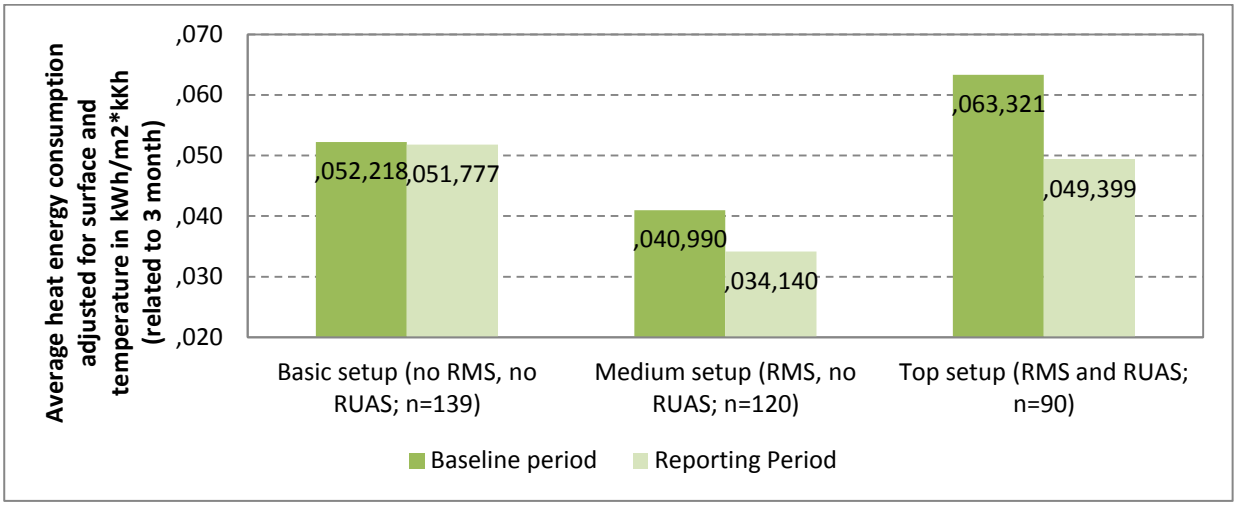


These results correspond with the concentrated efforts of the housing provider on buildings with high need for action. As shown below, the top setup was installed in dwellings with much higher

[26] The consumption figures are always sorted in ascending order from left to right.

average baseline consumption compared to the other sites which could be reduced to a rather "normal" consumption level within the project duration.

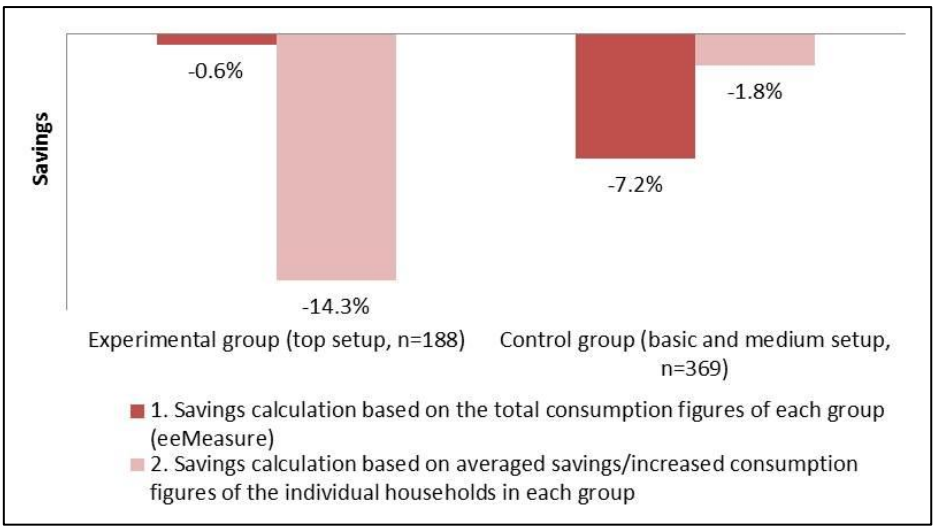
Figure 4.2.5: Average adjusted heat energy consumption in kWh/m²*kKh (3-month observation period) related to all setups in Darmstadt



Hot water

Whatever the calculation approach is, the experimental group as well as the control group achieved hot water savings. The difference between both groups is statistically not significant[27]. That means that an impact of the offered RUAS is not obvious, which seems to be mainly due to the low number of RUAS users in the experimental sample.

Figure 4.2.6: Percentage change in hot water consumption related to RUAS experimental and control group

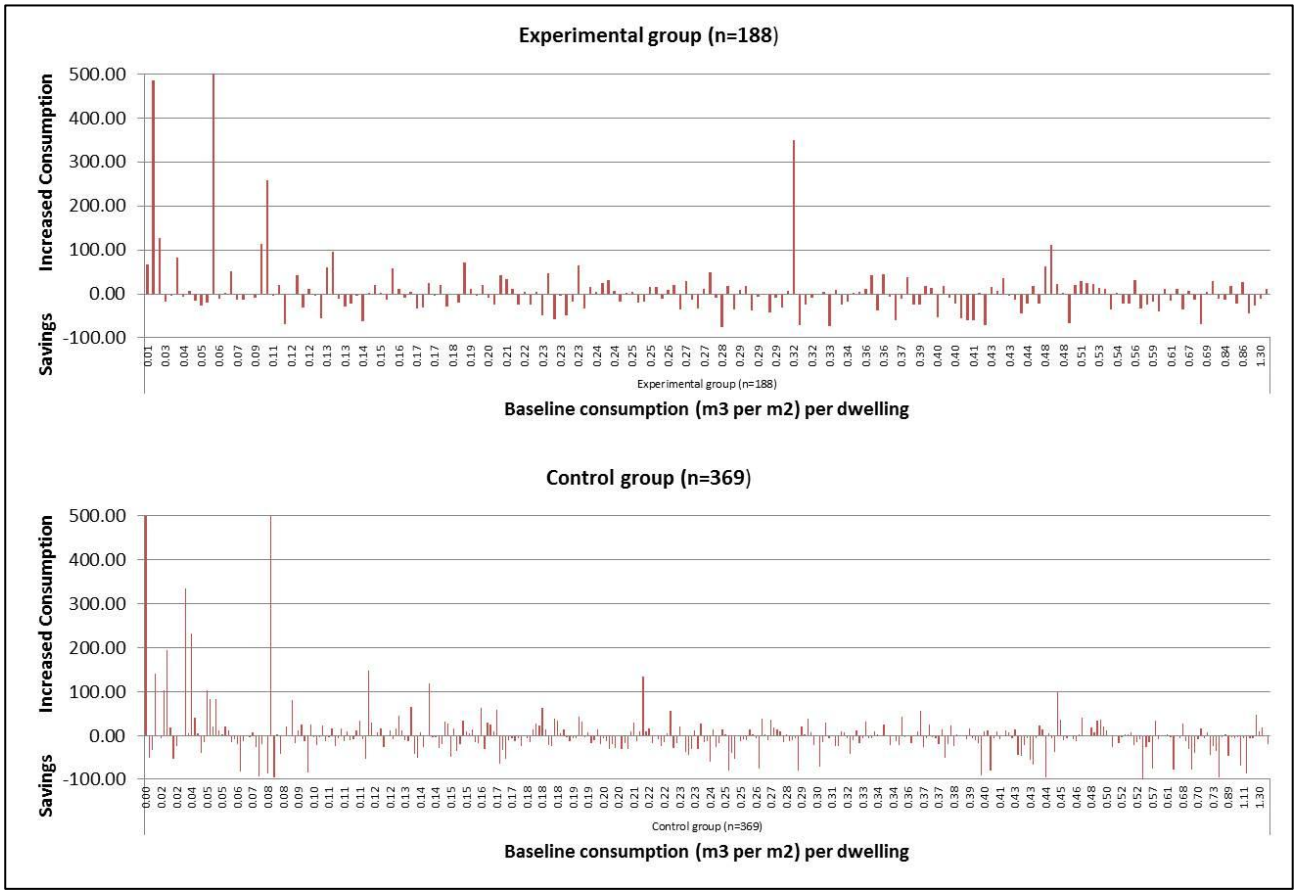


Four of the seven RUAS portal users achieved savings of 16% on average. In contrast to that, the three remaining users had an increase of 48% on average.

[27] Calculated with t-test based on the individual saving figures of calculation model 1

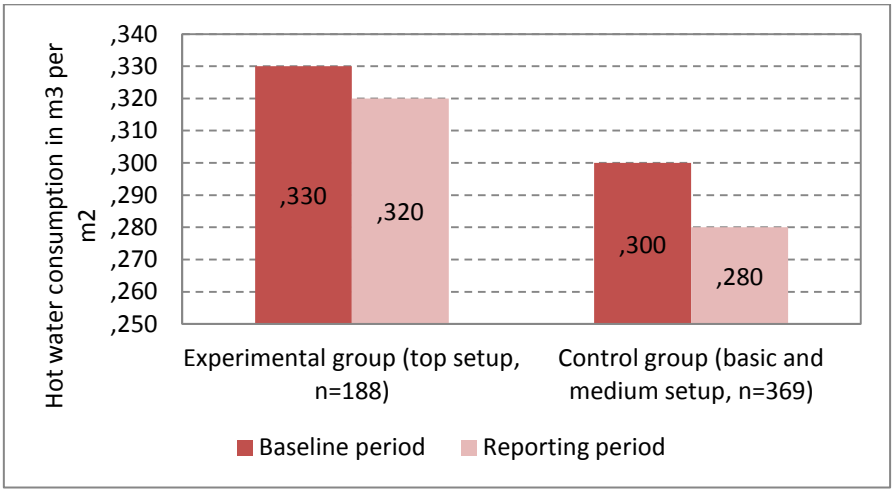
The differences in the above presented saving figures are again due to the divergent calculation models because extreme values – which could be still realistic – carry weight in different directions (see following figure).

Figure 4.2.7: Savings resp. increased consumption per household related to the baseline hot water consumption (in m^3/m^2)



Both groups have very similar consumption figures per square meter which had to be used for calculation instead of the missing household sizes.

Figure 4.2.8: Hot water consumption in m^3 per m^2 related to RUAS experimental and control group



Even more tenants of the control group (60% compared to 53% of the experimental group) achieved savings of 23% on average. Nevertheless, the average consumption reduction is a bit higher for experimental households with savings (26%).

Table 4.2.5: Percentage of dwellings with hot water savings/increased consumption and correspondent average figures related to RUAS experimental and control group

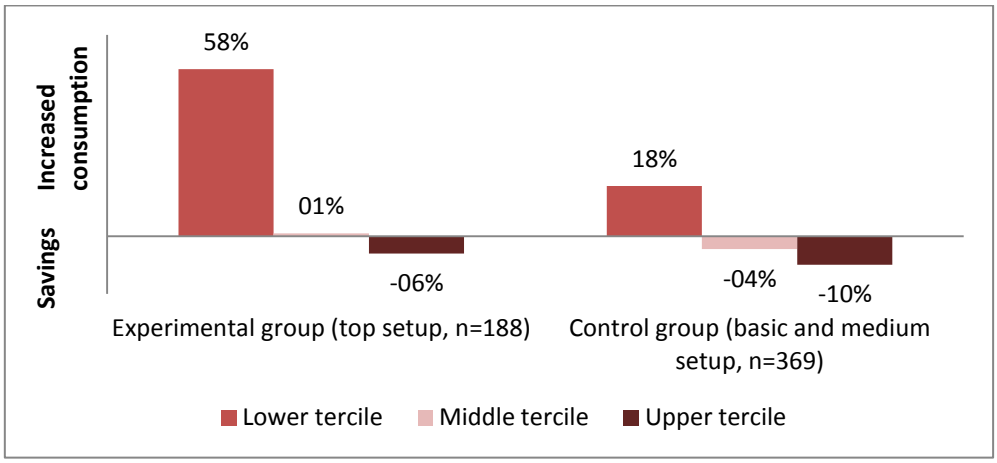
	Exp. Group*	Contr. Group**
Absolute number and percentage of dwellings with savings	99 (53%)	222 (60%)
Average savings of dwellings with savings	-26.2	-22.7
Absolute number and percentage of dwellings with increased consumption	88 (47%)	142 (40%)
Average increased consumption of dwellings with increased consumption	+60	+40

* plus one household with unchanged consumption figure

** plus five households with unchanged consumption figures

As the following figure shows, especially the high consumers (upper tercile) in both groups achieved savings.

Figure 4.2.9: Percentage change in hot water consumption related to consumption terciles[28] in each comparison group



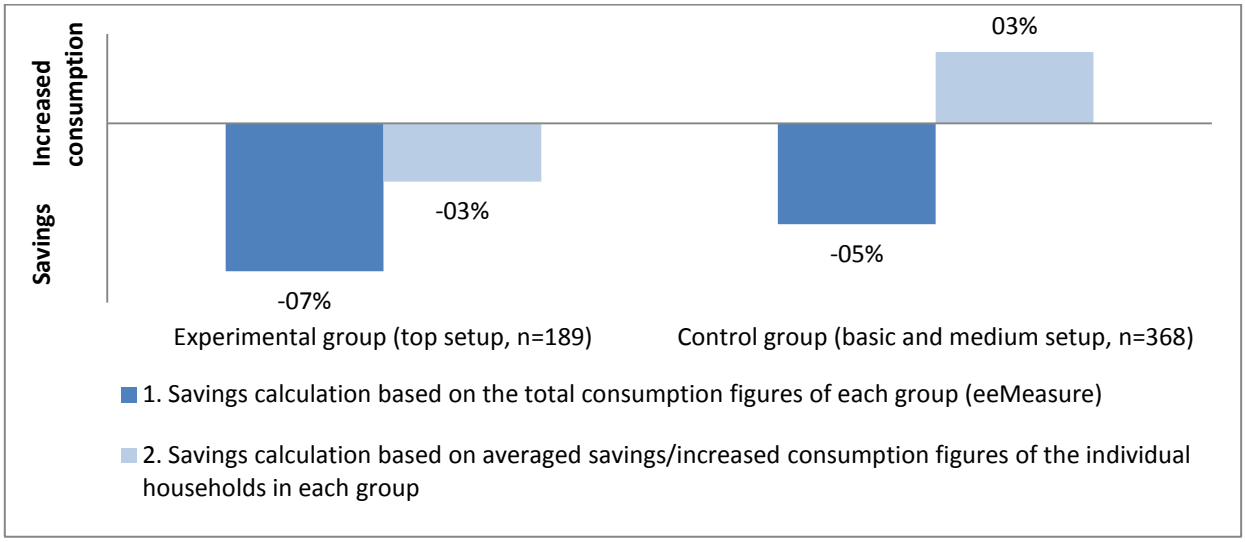
Cold water

The experimental group achieved savings independently from the used calculation approach. However, the difference between both groups is statistically not significant as a t-test based on the individual saving figures of calculation model 2 showed. That means again that the RUAS has no measurable impact on water consumption which is very likely due to the low interest in the tenant portal.

Four of the seven RUAS portal users achieved savings of 7% on average. In contrast to that, the three remaining users had an increase of 8.5% on average.

[28] The terciles were always calculated based on the baseline consumption per square meter in each dwelling.

Figure 4.2.10: Percentage change in cold water consumption related to RUAS experimental and control group



The differences in the above presented saving results are again due to the differences in calculating these savings. The both following figures show that especially high consumers in the control group had large consumption reductions.

Figure 4.2.11: Savings resp. increased consumption per household related to the baseline hot water consumption (in m^3/m^2)

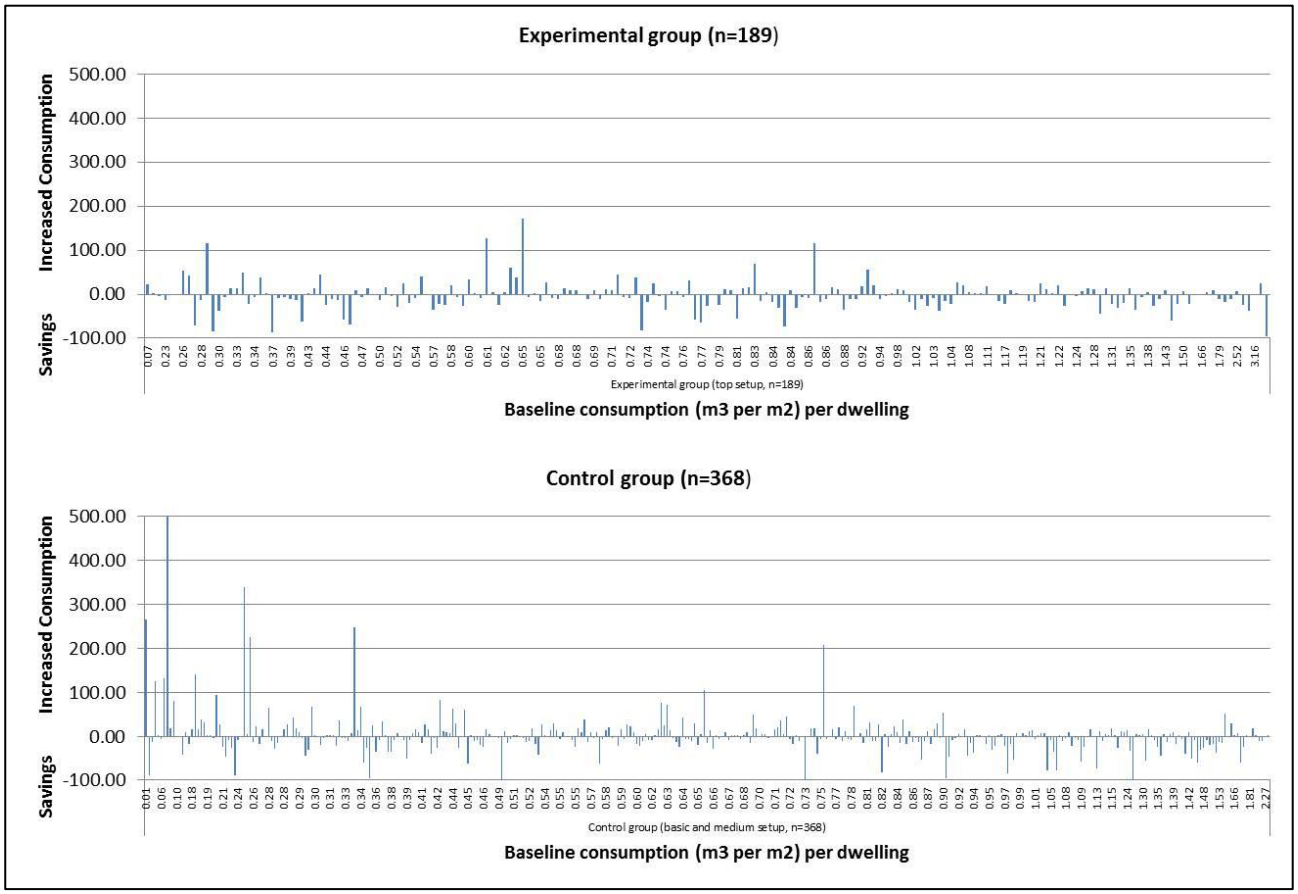
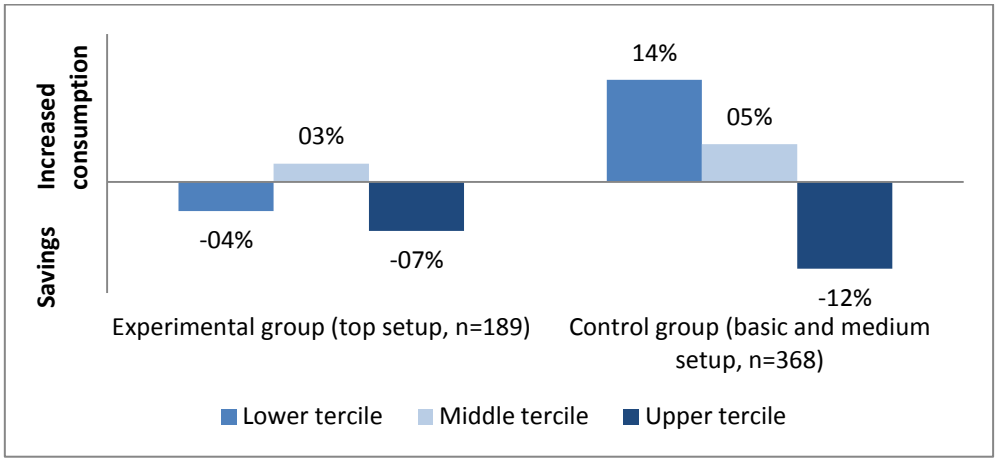
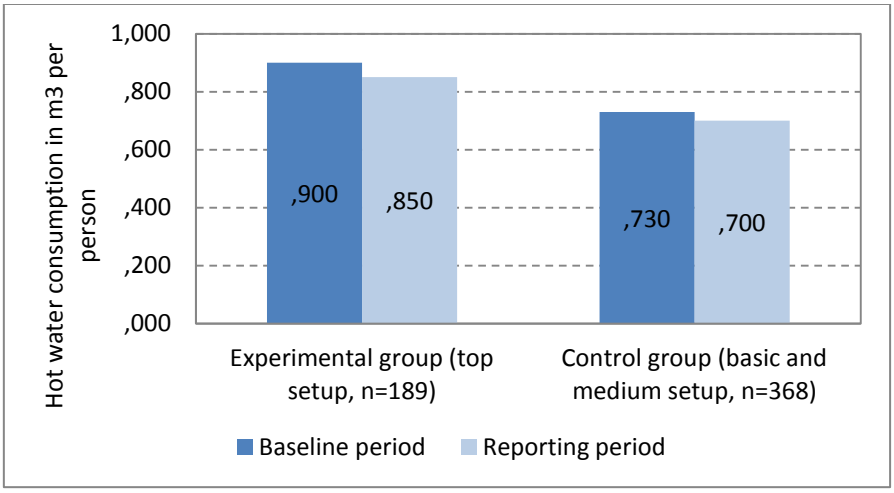


Figure 4.2.12: Percentage change in cold water consumption related to consumption terciles in each comparison group



The computation of the shown terciles based again on the baseline consumption per m^2 in each dwelling which was on average nearly 20% lower in the control group compared to the experimental group.

Figure 4.2.13: Cold water consumption in m^3 per m^2 related to RUAS experimental and control group



However, relatively more tenants of the experimental group (56% compared to 52% in the control group) achieved cold water savings of about 22%.

Table 4.2.6: Percentage of dwellings with cold water savings/increased consumption and correspondent average figures related to RUAS experimental and control group

	Exp. Group*	Contr. Group**
Absolute number and percentage of dwellings with savings	106 (56%)	193 (52%)
Average savings of dwellings with savings	-22.4	-21.0
Absolute number and percentage of dwellings with increased consumption	81 (43%)	173 (47%)
Average increased consumption of dwellings with increased consumption	+23.3	+30.3

* plus two household with unchanged consumption figure

** plus two households with unchanged consumption figures

4.2.3 Results of survey analysis

Results of mid-term survey

In Darmstadt the mid-term survey was conducted with seven tenants who are using the tenant portal. Their answers give a positive picture of the portal.

The login process and further aspects of using the portal were without difficulty for the seven tenants. All tenants stated the figures provided in the portal as easily understandable. Nobody was reporting on any specific problem or on parts of the portal that have been uncomfortable.

The portal was predominantly described as informative; one person characterised it as helpful. Nevertheless, four tenants gave feedback for further improvements. They initiate to have (more) reference data, to get some information more clearly resp. more comprehensibly and to provide also energy bills.

All respondents were active users. Most of them log in twice a month, two persons log in once a month and one person quarter-annually.

The portal use mainly seems to be a task of one responsible person in a multi-person household because only in one of the relevant five households the portal is also known by the partner. However, all five respondents speak about the portal with their partners.

The majority of tenants reported that they already tested the energy saving tips provided by the portal. One person had the opinion that this is not necessary as he/she already behaves in pro-ecological manner.

All of them intend to use the portal in future. A majority also want to try to change their energy using habits. Another person reported that he/she already changed the consumption behaviour.

Data basis and profile of respondents at baseline and final survey

The following table shows the number of respondents related to the survey stages. It becomes obvious that it was difficult to motivate tenants for participation in the survey. In the baseline survey 150 out of 675 tenants (22%) participated whereas 120 respondents belong to the control group (response rate: 26%) and 30 respondents belong to the experimental group (response rate: 13%). This shows that it was especially difficult to motivate tenants of the experimental group for participation in the baseline survey. At the final stage the number of respondents decreases down to 37 respondents in the control group (response rate: 8%) and ten persons in the experimental group (response rate: 5%). This results in a very low number of tenants who participated in both panel stages (12 persons in control group and 2 persons in experimental group).

Table 4.2.7: Number of respondents per survey stage

Participation at survey stage	Evaluation Group		Total
	Control Group	Experimental Group (RUAS)	
Only baseline survey	108	28	136
Only final survey	25	8	33
baseline and final survey	12	2	14
Total	145	38	183

As a consequence pre-post comparisons are not possible due to these small sample sizes. That means the survey analyses follow a control group approach and are restricted to comparisons of tenants of both groups who participated at least in the final stage (10 persons in experimental

group, 37 tenants in control group). Therefore the results can only draw a rough picture of the influence of the RUAS services.

Table 4.2.8 gives an overview on the profile of the survey participants. Focussing on tenants who participated in the final survey, some differences in the profile of control group tenants and experimental group tenants become obvious. So the respondents of the control group are older on average than in the experimental group (Median: 52 versus 45 years), the size of the households consists of two persons in control group and three persons in the experimental group and the time of absence from home of all household members is slightly longer in the control group than in the experimental group. On the other hand, in both groups there are more female than male respondents, the majority of respondents were born in Germany and the level of education is widely spread.

Table 4.2.8: Profile of respondents in relation of survey participation (frequency)

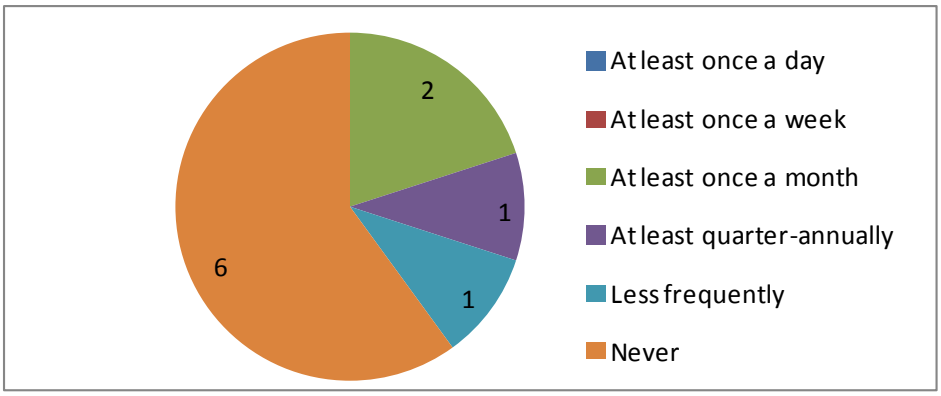
Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		Control Group (n=37)	Exp. Group (RUAS) (n=10)	Control Group (n=12)	Exp. Group (RUAS) (n=2)
Sex	Male	13	1	3	0
	Female	24	9	9	2
Country of birth	Germany	23	7	6	0
	Other	14	3	6	2
Age	Mean	53 years	47 years	51 years	37 years
	Median	52 years	45 years	49 years	37 years
Level of education	No school leaving qualification	1	0	0	0
	Primary/secondary school leaving qualification	12	3	6	0
	Secondary school leaving qualification	11	2	1	1
	University entrance qualification	6	3	3	0
	University/university of applied science degree or Doctorate	7	2	2	1
Size of household	Median (persons)	2 persons	3 persons	3 persons	3 persons
Absence of all household members at normal week day	0-2 hours	16	2	5	0
	3-5 hours	8	5	3	0
	6-8 hours	7	2	2	2
	More than 8 hours	4	1	0	0
Rent or service Charges paid by municipality	No	n/a	n/a	n/a	n/a

RUAS use and motivation of tenants

Based on the ten tenants of the experimental group who participated at the final survey, it becomes obvious that the tenants mostly were not motivated to make use of the tenant portal. There are two persons who log in the portal at least once a month, one person at least quarter-annually and one more person less frequently. This means that only three persons of the sample can be determined as active portal users.

The three active users are all female and between 65 and 74 years old. One person is living together with three further persons in her household. The other two women are living alone.

Figure 4.2.14: Frequency of portal use
(n=10; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

Considering the motivation to save energy at final stage, some differences between experimental group and control group can be found. There are more tenants who are motivated by environmental aspects in the experimental group (3 persons) than in the control group (1 person). Additionally, nobody in the experimental group feels motivated solely by saving money whereas in the control group eight persons have this opinion. Nevertheless, the majority of tenants in both groups feel motivated by both saving money and protecting the environment.

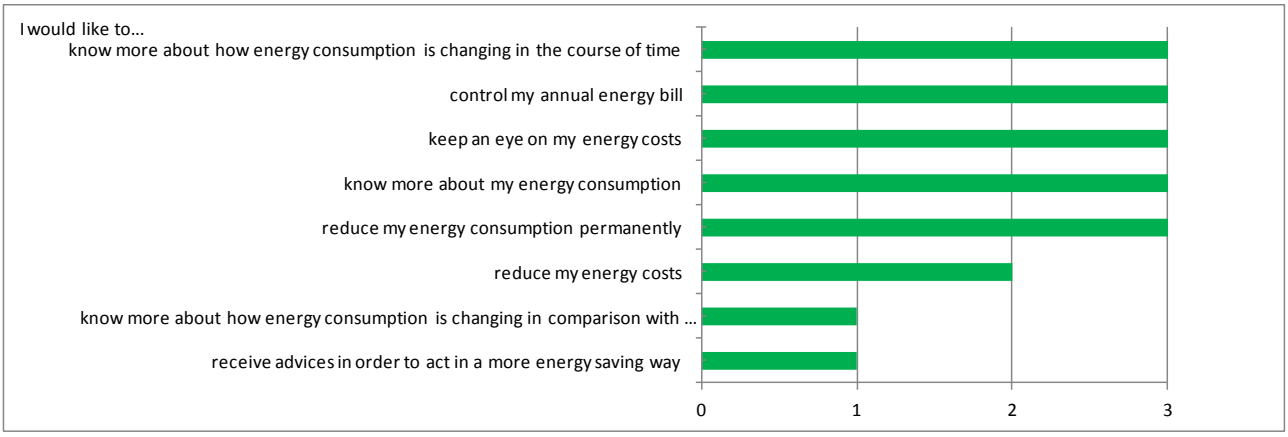
This means that an intrinsic motivation of protecting the environment seems to be slightly higher in the experimental group. But it cannot be clarified why this motivation is not resulting in a higher number of active portal users. Maybe they don't feel confident yet that the portal or their individual behaviour can contribute to the protection of the environment.

Among the three active users, both kind of motivation are equally represented. So there is one person who reported to be motivated solely by the monetary aspect, one person by the environmental aspect and another person by both aspects equally.

Reasons for using and for not using the tenant portal

Figure 4.2.15 shows that all three active users would like to know more about their energy consumption in general and its development over time and that they want to reduce their energy consumption permanently. On the other hand the control of energy costs is important for them. So they want to keep an eye on their costs and to control their energy bill. But only two persons would like to reduce their energy costs. Receiving advices in order to act in a more ecological way and knowing more about the energy consumption in comparison with other households are reported by one person only.

Figure 4.2.15: Reasons for using the tenant portal
(n=3; active users; frequency for "I strongly agree")



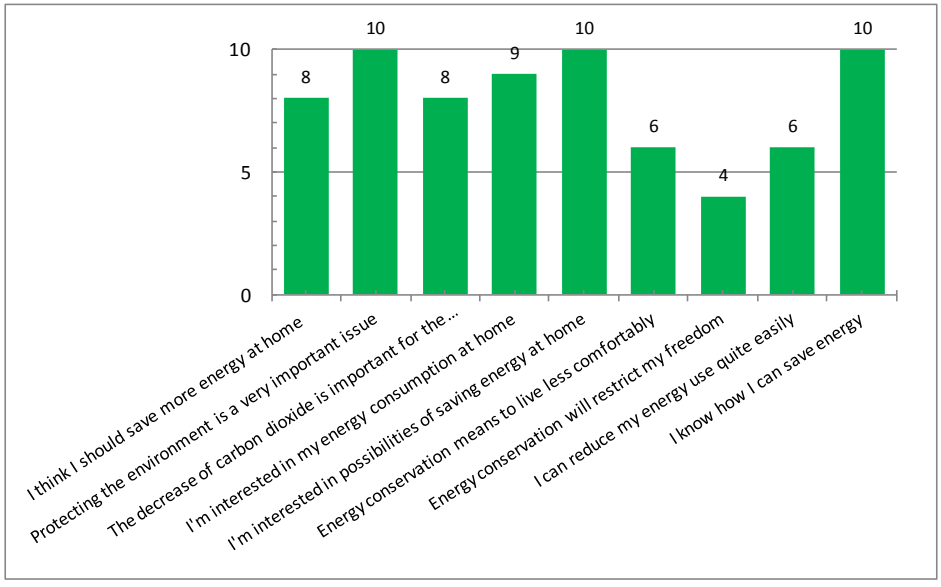
Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

The reasons for not using the tenant portal are partly directly related to the tenant portal ("I don't know how the tenant portal works") or the medium used ("I prefer information on paper"). Other reasons are related to the fact that the already available information (e.g. annual bill) is considered as sufficient or that alternative channels are used to learn more about energy saving issues. For each of these described reasons, there is always one person who strongly agrees with it.

Impact on ecological awareness

Even if a real impact analysis is not possible due to the small sample sizes, a comparison between tenants of the experimental group and tenants of the control group can be made.

Figure 4.2.16: Ecological awareness of experimental group tenants at final stage
(n=8-10 due to missing values); frequency for answer categories "strongly agree and rather agree")



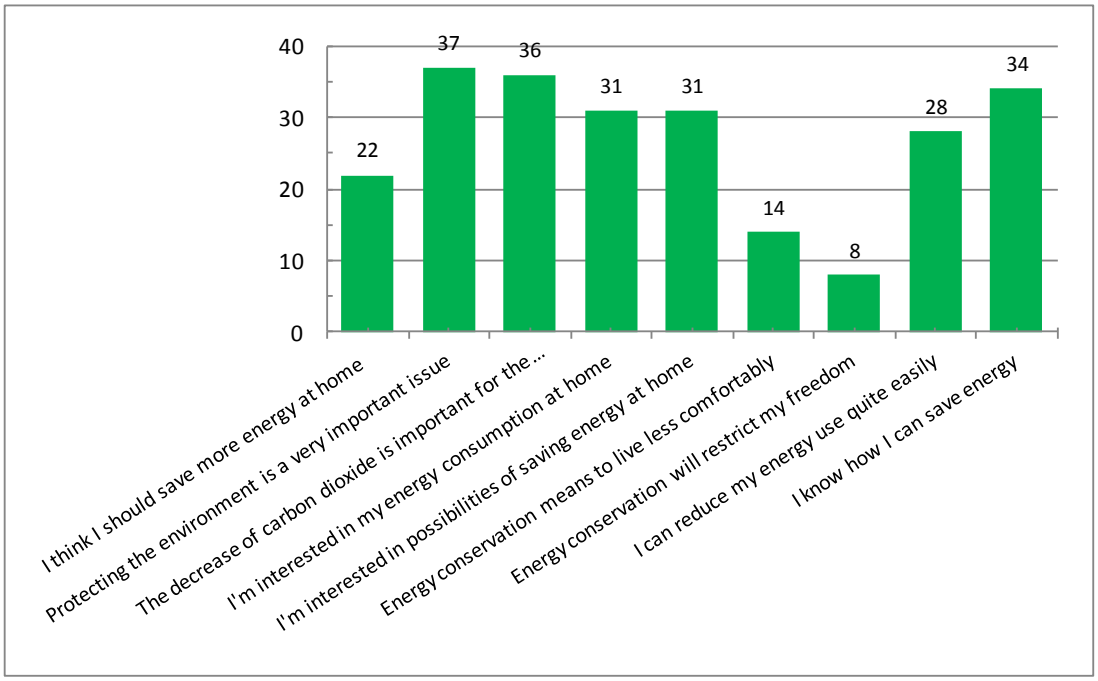
Survey question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

The above figure shows the absolute frequencies (as percentages are not useful due to small sample sizes) for the answer categories "strongly agree" and "rather agree" of the experimental group at the final stage. It shows that there is a high level of ecological awareness in the

experimental group. The interest in the own energy consumption and the possibilities to save energy is high because nine respectively all ten tenants strongly or rather agree to these statements. All tenants also agree that protecting the environment is an important issue. Furthermore it becomes obvious that all tenants feel well informed about how they can save energy. Nevertheless, only six tenants think that it is easy for them to save energy. A good result represents the lower affirmation of the statements related to restrictions in freedom and comfort as only four resp. six tenants agree with them.

In comparison to the experimental group, the frequencies of control group tenants who strongly or rather agree to the statements seem to be somewhat lower. Related to all statements there is a greater variance of opinions than in the experimental group. This means that the experimental group shows a larger consensus in their almost pro-ecological awareness. At the same time control group tenants have more seldom the opinion that energy conservation will restrict their freedom or means to live less comfortably. This might be due to the fact that they did not try as many possibilities to save energy as the experimental group.

Figure 4.2.17: Ecological awareness of control group tenants at final stage
(n=32-37 due to missing values); frequency for answer categories “strongly agree and rather agree”)



Survey question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don’t know.

Only three persons responded the retrospective questions whether the tenant portal has contributed to raise their knowledge about their energy consumption and to keep an eye on their energy consumption or not. All of these three persons think that they now know more about their energy consumption (yes: 2 persons, rather yes: 1 person). Two persons keep an eye on their energy consumption due to the tenant portal, but one person does not.

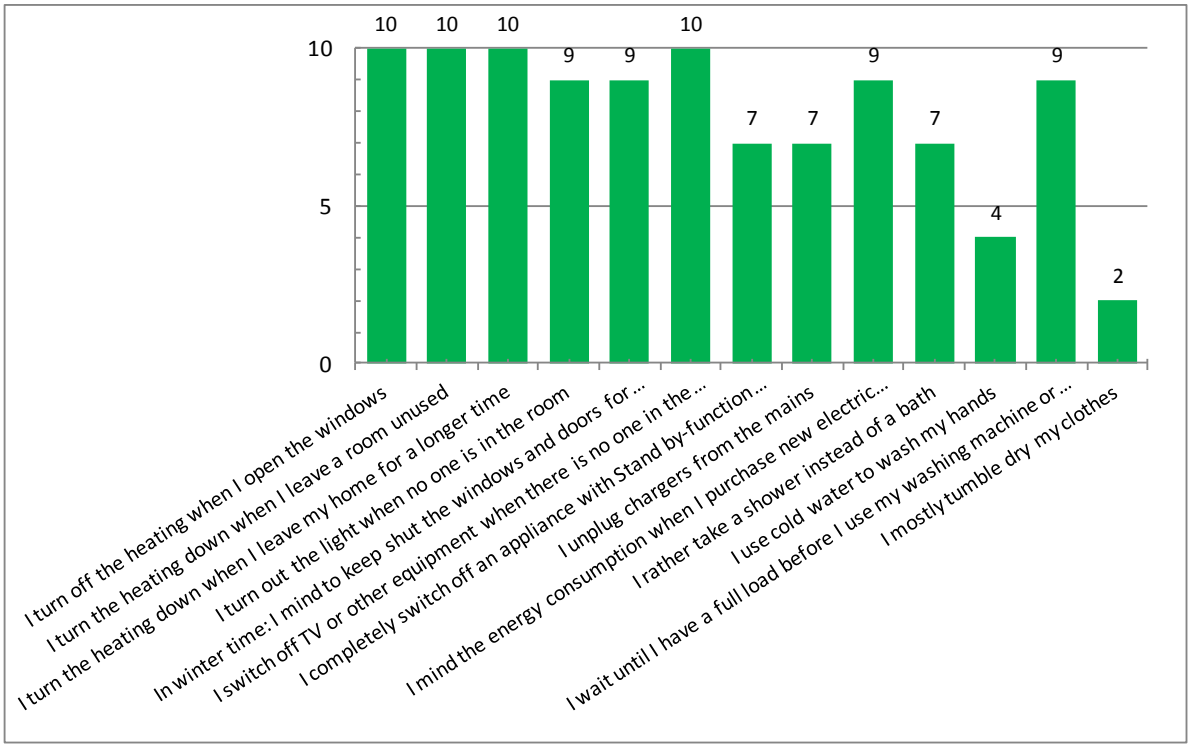
In general, a high ecological awareness can be found in the experimental group as well as in the control group, but the experimental group shows slightly better results and a greater consensus of their positive opinions within the group. Although these results can be seen as indicators of the positive influence of the tenant portal on ecological awareness, an interpretation must be treated with caution due to the very small sample sizes. For example, it is not known whether the ecological awareness improved over time or the experimental group tenants already showed a higher awareness before the operation of the tenant portal. The impression of this small influence of the tenant portal is mainly confirmed by the statements about changes in knowledge and the relevance of the own energy consumption.

Impact on ecological behaviour

The ecological behaviour is examined by means of several statements and the level of agreement with them.

The following figure shows the numbers of persons who strongly agree or rather agree with the statements after the portal was offered to the tenants of the experimental group.

Figure 4.2.18: Ecological behaviour of experimental group tenants at final stage
(n=8-10 due to missings[29]; frequency for answer categories “strongly agree and rather agree”)



Survey Question: There are different ways people act in their everyday life. To what extent do you agree or disagree with the following statements?
Answer categories: “strongly agree”, “rather agree”, “neither agree nor disagree”, “rather disagree”, “strongly disagree”, “Don’t know”; “not applicable”

The experimental group shows a high level of ecological behaviour. This is especially true for actions related to heat energy: All ten tenants of the experimental group are turning off the heating when opening the windows, turning the heating down when a room is left unused or when they

[29] Answer categories „not applicable” and “don’t know” were coded as missing.

leave their home for a longer time. Nine of them keep windows and doors of commonly used rooms shut in winter time.

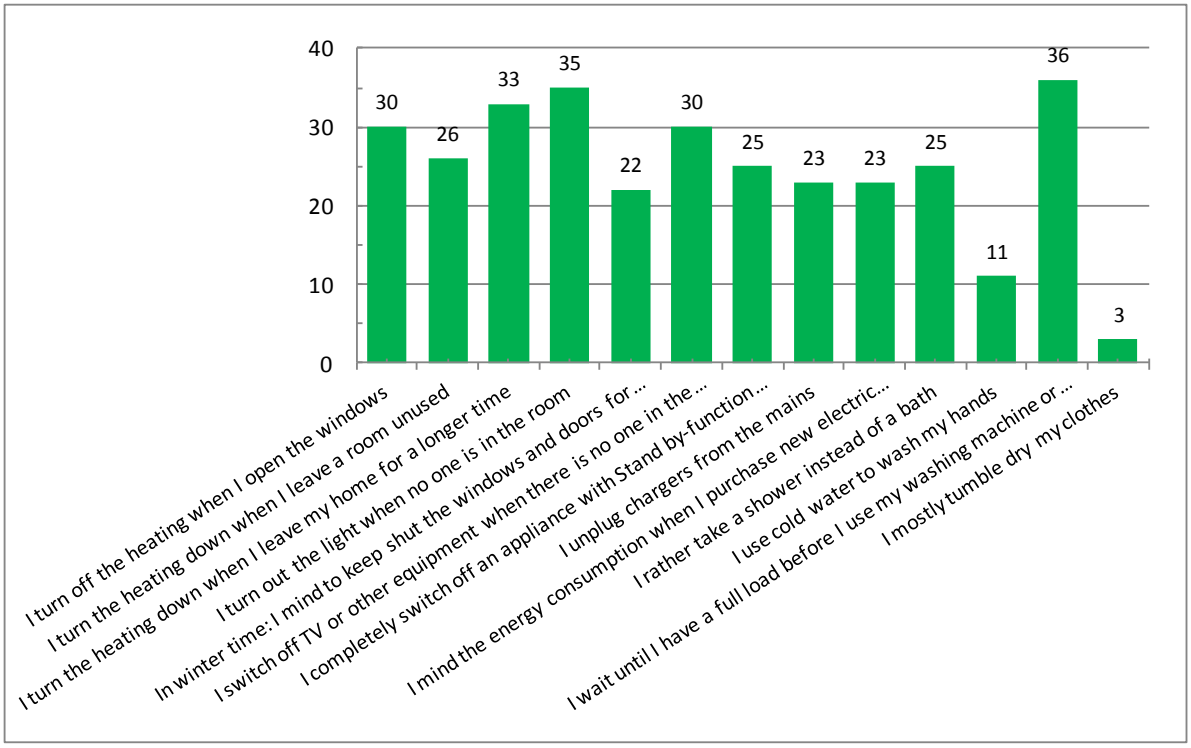
With relation to water the results are mixed. Nine of ten tenants wait until they have a full load before starting washing machines or dishwashers, but only seven take a shower instead of a bath and only four of them use cold water for washing their hands. A reason could be that those behaviour patterns are partly assessed as uncomfortable and therefore not habitually practiced.

Further findings related to electricity consumption, which was not part of the particular RUAS in Darmstadt, differ again: So all tenants switch of TV or other equipment when nobody is in the room, nine respondents consider the energy consumption when purchasing new electric appliances, only two persons mostly tumble dry their clothes. But on the other hand, seven persons at maximum completely switch off appliances with Stand by-function or unplug charger from the mains.

In summary, there are higher levels of ecological behaviour related to resources that are part of the services which can be interpreted as an influence of the RUAS.

The comparison with the reported behaviour of the control group confirms this impression. Related to all behaviour patterns asked for, there are smaller proportions of tenants behaving desirably. That is especially true for heat energy consumption (e.g. turning the heating down when leaving a room unused, keeping windows and doors of commonly used rooms shut in winter). A high level of ecological behaviour that is similar to the experimental group is related to such actions as doing the laundry and the dishes (I wait until I have a full load before using the washing machine / dishwasher) and using a tumble dryer.

Figure 4.2.19: Ecological behaviour of control group tenants at final stage
(n=23-37 due to missings[30]; frequency for answer categories “strongly agree and rather agree”)



Survey Question: There are different ways people act in their everyday life. To what extent do you agree or disagree with the following statements?
Answer categories: “strongly agree”, “rather agree”, “neither agree nor disagree”, “rather disagree”, “strongly disagree”, “Don’t know”; “not applicable”

[30] Answer categories „not applicable” and “don’t know” were coded as missing.

At the same time a lower level is evident – again similar to the experimental group – for actions related to electricity consumption (unplugging chargers from mains, switching off appliances with stand by-function) and using cold water to wash hands.

That means in general, that indications for a positive influence of the RUAS services are given mostly related to heat energy consumption. But again, these findings has to be interpreted carefully because it is not reliably known whether the shown differences between control group and experimental group are biased due to the small sample sizes or have already been existing before the operation of the services.

Ventilation behaviour

The ventilation behaviour shows no remarkable differences between experimental group and control group. Again tenants of both groups mainly show an already optimal behaviour when opening windows widely at times or leaving windows open ajar only at short times. Again the validity of these results is restricted.

Retrospective and prospective behaviour

Among the three active users who have reported on their behaviour retrospectively as well as on their future behaviour, one tenant stated to have already changed behaviour due to the portal usage. Two tenants denied this statement. However, all three tenants intend to conserve heat energy next winter as well as electricity / water in future.

In summary, it can be stated that there exist some indications of a positive influence of the RUAS services especially on heat energy consumption. However, this interpretation has to be treated carefully as it does not base on robust analyses due to very small sample sizes.

Satisfaction with tenant portal and prospective portal use

Information about the satisfaction with the tenant portal is available from three persons only who represent the active portal users:

- All three persons are very satisfied with the tenant portal in general.
- Questions about the usefulness of the information presented are mainly answered by two persons. There are different opinions for all aspects asked for. An interpretation cannot be drawn on this basis.
- Questions about the handling with the tenant portal have been answered by all three persons. They are very satisfied with almost all aspects like the clarity of provided information, the comprehensibility of the consumption data, the amount of information and the manageability of the tenant portal. But only one person is very satisfied with the confidentiality of the provided information whereas the two other persons are neither satisfied nor dissatisfied.
- One person reported on problems that are occurred when using of the portal, but provided no information about the character of these problems.
- All three tenants intend to use the tenant portal at least once a month in future, but they are not willing to pay for the portal or a similar energy monitoring device.

In summary, the three active users are very satisfied with the manageability of the tenant portal. Different results can be found with regard to the usability of the provided information. The general usefulness of the portal is confirmed by the intention to continue the portal use in future.

4.2.4 Results of combined analysis

The consumption analysis in section 4.2.2 showed that – related to heat energy – especially the RMS had a big positive impact on consumption reduction, but is interfering with the influence of RUAS that was additionally restricted due to the small number of users. That's why the combined analysis will focus on cold and hot water consumption. It is of interest whether the ecological awareness and the behaviour of tenants are related to the resource consumption respectively savings or not.

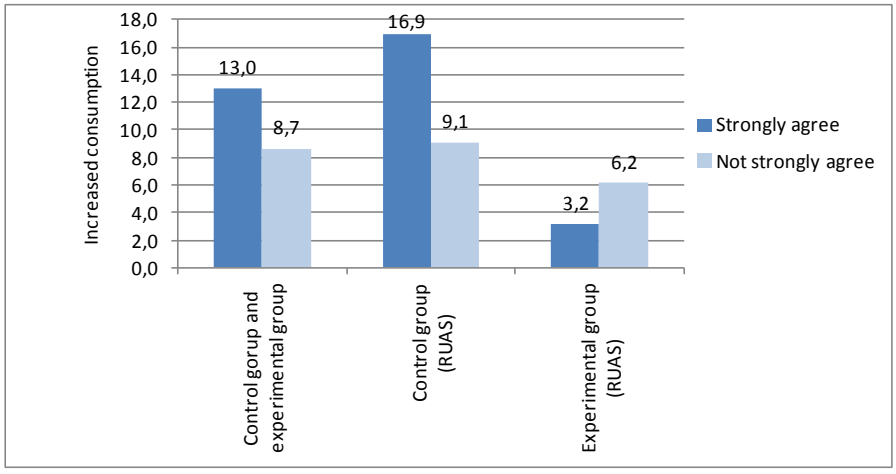
Subjective energy saving norm and water consumption

The following analysis shows the relation between the subjective energy saving norm (Item: "I think I should save more energy at home") and the percentage changes in cold and hot water consumption. As the survey data allowed no pre-post comparisons due to the low response rates, tenants with strong ("strongly agree") resp. without strong energy saving norm ("not strongly agree") measured at baseline stage will be compared.

Cold water consumption

In total there are increased consumptions of tenants with and without strong energy saving norm obvious. Based on all dwellings with available information about both subjective energy saving norm and cold water savings (experimental and control group together), tenants with strong energy saving norm have a much higher increase in cold water consumption than tenants without strong energy saving norm. But as the following figure shows that is especially caused by the tenants of the control group. In contrast, the experimental group tenants performed better when having a strong energy saving norm than tenants without one. This means that the energy saving norm serves as a driver for cold water consumption when there are additional saving campaigns available as for the experimental group.

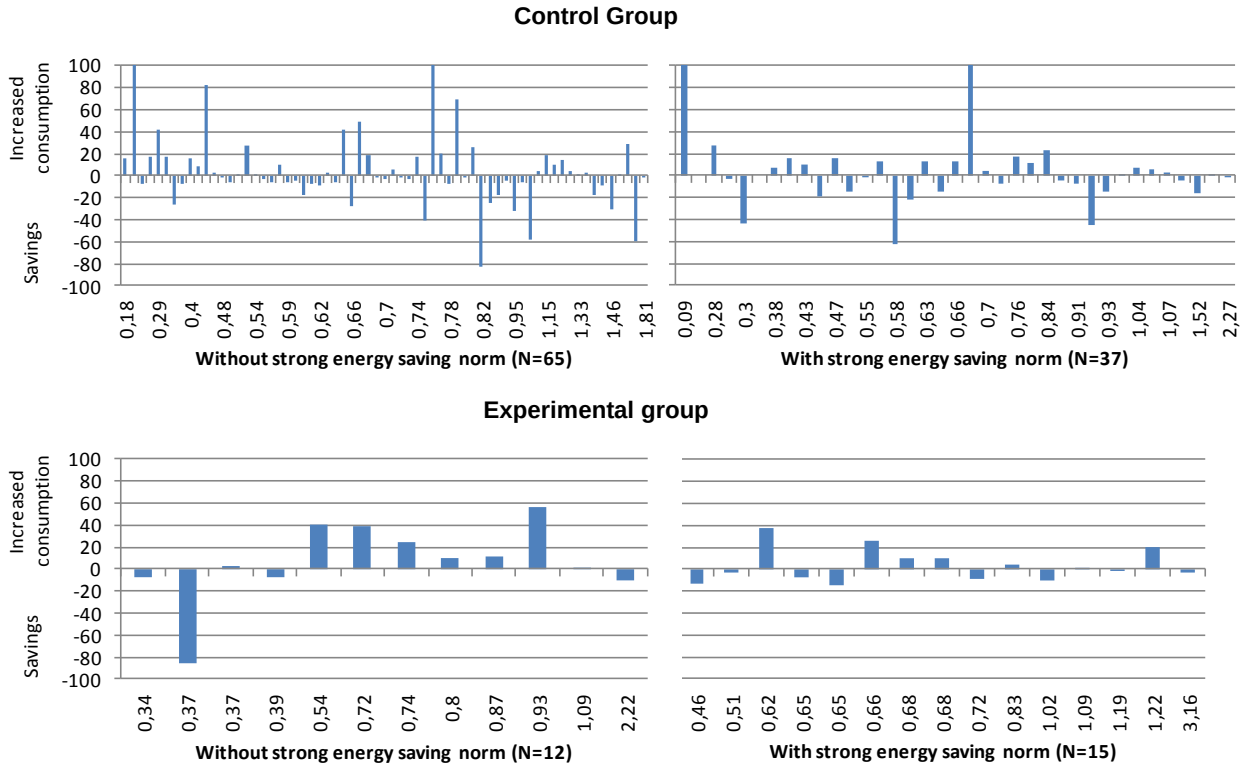
Figure 4.2.20: Percentage change in cold water consumption for tenants with and without strong energy saving norm



The consumption analysis also showed that the percentage change in water consumption is strongly related to the baseline consumption. That's why the following figure shows the percentage changes of tenants with and without strong energy saving norm in both comparison groups related to their initial consumption.

A correlation between baseline consumption and percentage changes can only be found for tenants without strong energy saving norm in the control group. Related to all other subgroups this relation is not obvious. This means that the influence of the energy saving norm is not generally related to the baseline consumption, but it overlaps the influence of the baseline consumption on the achieved savings. This is especially true for the experimental group where the influence of the energy saving norm seems to be stronger than the influence of the baseline consumption.

Figure 4.2.21: Percentage change in cold water consumption of tenants with and without strong energy saving norm related to baseline cold water consumption (in m^3/m^2)



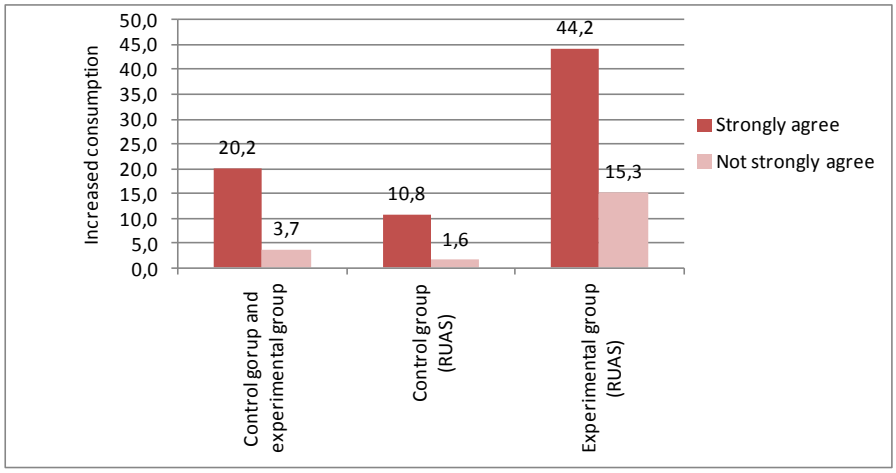
Independent from the baseline consumption, it can be observed that the energy saving norm has an influence on tenants of the experimental group because there were more households with savings or with smaller increases when tenants reported on a strong energy saving norm. 53% of experimental tenants with strong energy saving norm achieved savings. The same applies to only one third of tenants without strong energy saving norm. This trend is not obvious in the control group. This confirms the above result that the energy saving norm in combination with further influencing factors – e.g. energy saving campaigns – can be a driver for the achievement of savings. That's why, the effort to strengthen this attitude via RUAS services could help to achieve more savings.

Hot water consumption

With respect to hot water consumption, as before for cold water, there are also increased consumptions of all subgroups obvious. But in that context the experimental group shows the greatest difference between tenants with strong energy saving norm and tenants without that norm. So tenants with strong energy saving norm in this subgroup have consumed much more hot water than tenants without.

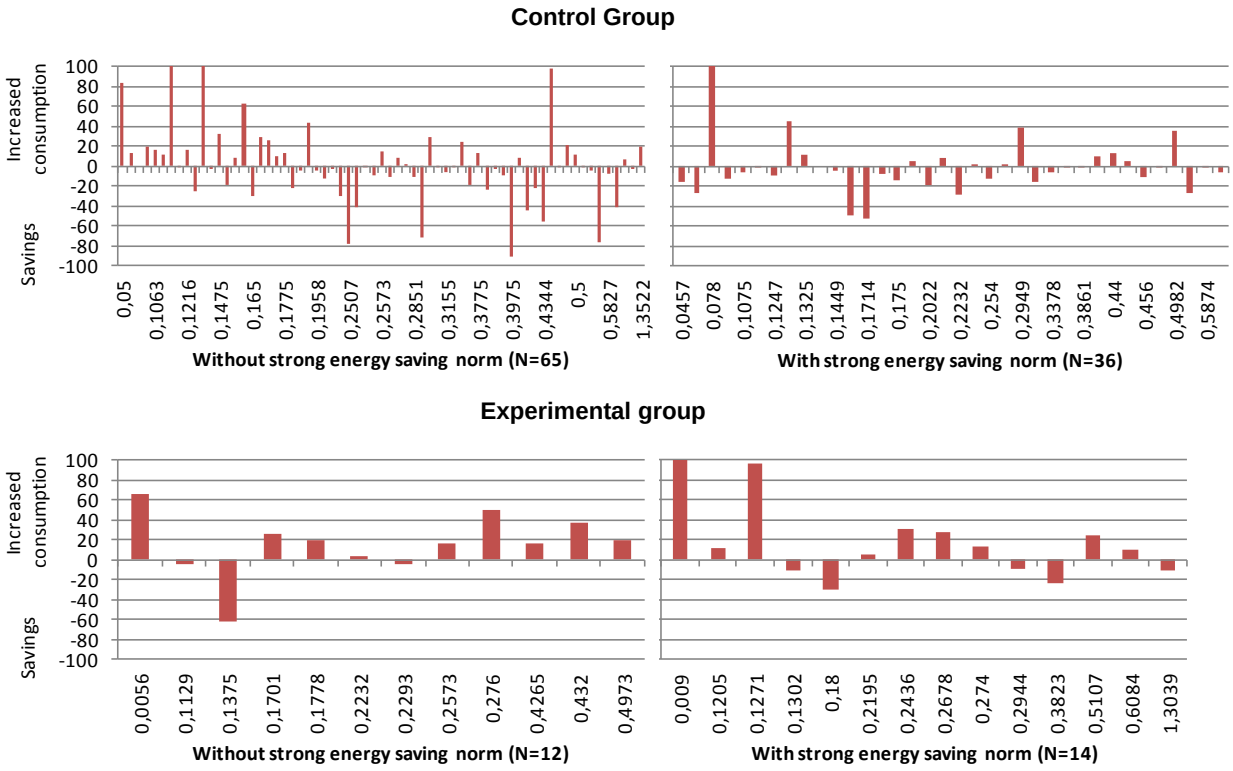
This might be again related to the baseline consumptions or could be due to outliers as the sample size especially for the experimental group is rather low (12 tenants without and 14 tenants with strong energy saving norm).

Figure 4.2.22: Percentage change in hot water consumption for tenants with and without strong energy saving norm



In contrast to the cold water consumption, a relation between baseline consumption and percentage changes in hot water consumption is mainly visible. In the control group especially the high consumers achieved savings. This can also be observed for experimental tenants with strong energy saving norm. This means that the relation between baseline consumption and percentage changes is not as much overlapped by the energy saving norm than it was seen for cold water consumption. Therefore the initial baseline consumption is of higher relevance for the hot water savings than for the cold water savings. That could be probably due to the higher price of hot water.

Figure 4.2.23: Percentage change in hot water consumption for tenants with and without strong energy saving norm related to baseline hot water consumption (in m^3/m^2)



However, independent from the baseline consumption, the energy saving norm shows an influence in both group because tenants with high energy saving norm more often achieved savings (64% in control group; 36% in exp. group) than tenants without energy saving norm (55% in control group; 25% in exp. group). This means that the influence of the energy saving norm is not obviously related to the evaluation group, but exists independently from the provision of services.

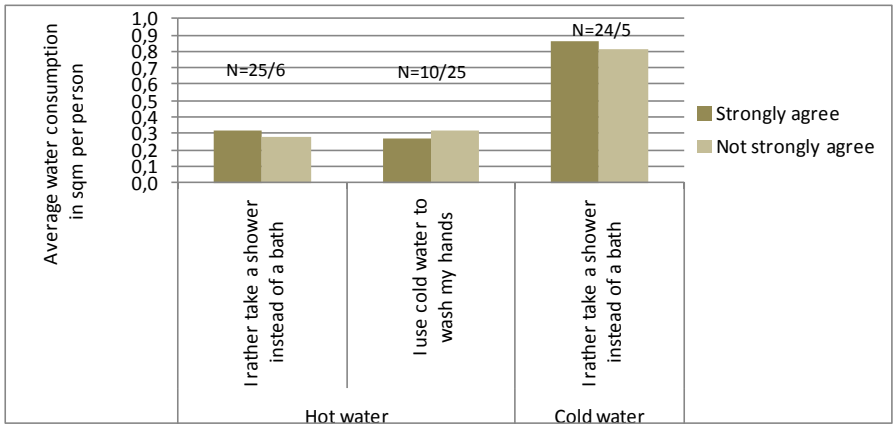
Everyday ecological behaviour and energy consumption

The relation between the actual ecological behaviour and the consumed energy is another important issue to examine. It can be assumed that the relation between behaviour and energy consumption is more directly than it is between the subjective energy saving norm and energy consumption.

Therefore the ecological behaviour reported in the final survey was analysed with regard to the measured cold and hot water consumption during the reporting period. For the water consumption the items “I rather take a shower instead of a bath” and “I use cold water to wash my hands” are relevant.

The following figure suggests that the two behaviour items are not related to the energy consumption during the reporting period as there are nearly no differences obvious between tenants with (“strongly agree”) and without (“not strongly agree”) ecological behaviour.

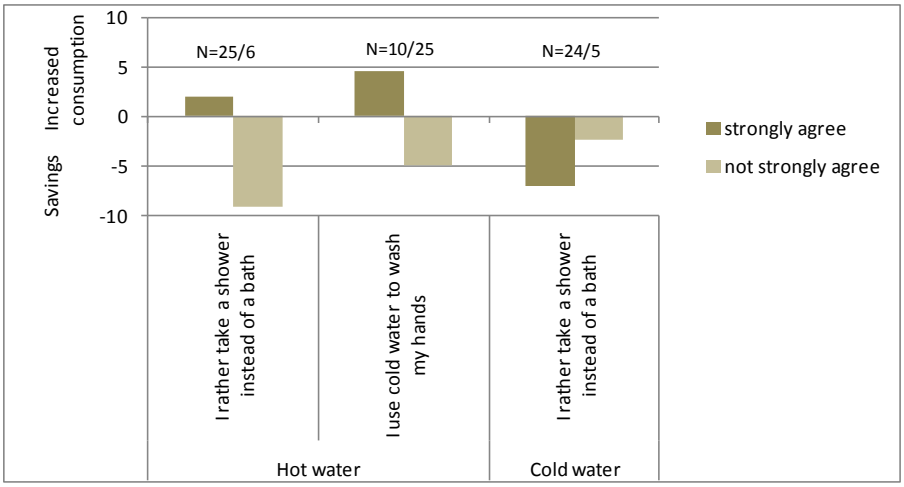
Figure 4.2.24: Water consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



However, considering the influence of the behaviour item on the achieved savings respectively increased consumptions, an influence can be found at least for the item about taking a shower instead of a bath on the cold water consumption. Tenants with self-reported ecological behaviour have saved 7.0% cold water whereas tenants without ecological behaviour have saved 2.4% cold water.

For the hot water consumption the results do not show the expected results. That’s why this relation shall be examined in more detail.

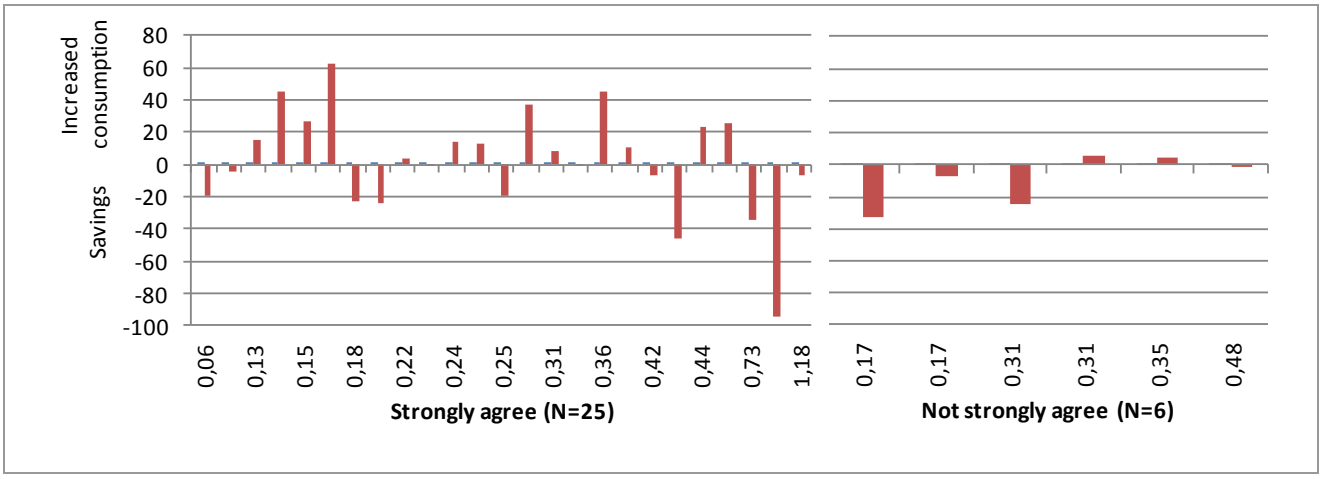
Figure 4.2.25: Percentage change in water consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



As in the above analysis there was noticed a relation between the achieved savings/increased consumption and the initial baseline consumption, the following figure shows the dwelling-wise percentage changes in hot water consumption in relation to the baseline consumption. As before related to the influence of the energy saving norm, there seems to be an influence of the initial baseline consumption that at least becomes obvious for tenants with ecological behaviour. This means that an ecological behaviour gains influence with increasing baseline consumptions.

It can also be seen that the better average performance of tenants without ecological behaviour is due to the fact that there are no tenants with remarkable increased consumption, but one tenant with a rather high saving whereas the percentage changes in the subgroup of tenants with ecological behaviour vary largely in both directions. However in both subgroups approximately half of tenants achieved savings, whereas the tenant group with ecological behaviour achieved higher average savings (-23.3%) than the tenants without ecological behaviour (-16.3%).

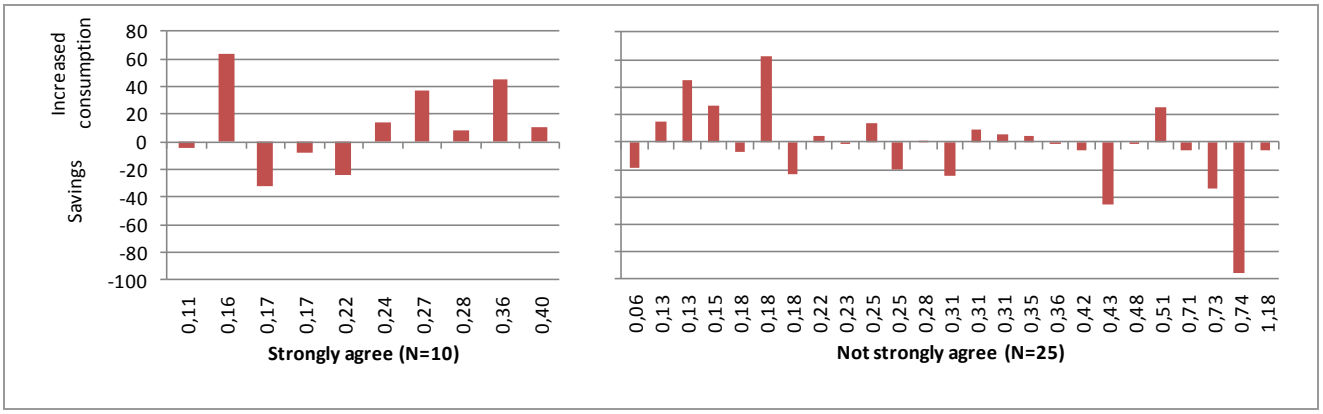
Figure 4.2.26: Percentage change in hot water consumption for tenants with and without ecological behaviour related to the baseline hot water consumption: I rather take a shower instead of a bath



With respect to the behaviour item “I use cold water to wash my hands” the same analysis shows that the relation between initial baseline consumption and percentage change in hot water consumption is obvious only for tenants without ecological behaviour. But it has to be pointed out that in this tenant group higher baseline consumption and savings can be found especially for

tenants with baseline consumption of at least 0.40m^3/m^2 which represents the maximum baseline consumption of tenants with ecological behaviour.

Figure 4.2.27: Percentage change in hot water consumption for tenants with and without ecological behaviour related to the baseline hot water consumption: I use cold water to wash my hands



Generally, the influence of the reported ecological behaviour for both behaviour items seems to be less relevant for the achieved savings than the baseline hot water consumption which can be seen as a major driver of hot water savings. However, when having rather high baseline consumption, the ecological behaviour gains influence on the achieved savings. This means that the better performance of the RUAS tenant group that has been noticed in the consumption analysis (section 4.2.2) cannot be explained by the behaviour items. But is has to be pointed out that this can be caused by the much lower sample size within the combined analysis.

4.3 Havirov

4.3.1 Background information

Havirov focussed on RUAS only including heat energy and domestic hot and cold water. The service consists of a tenant web portal giving tenants feedback about their household's consumption. Additionally the tenants receive e-mails and postal reports. Related to the two pilot buildings (Jabůrkové and Uzavřená) there were offered two different setups of RUAS: Consumption feedback on heat energy was available in both properties, but additional data on hot and cold water consumption were only provided in Jabůrkové.[31] A pre-defined control group was not available.

Figure 4.3.1: Screenshots of RUAS tenant portal

RUAS started operation in November 2012. The comparison periods cover in each case 11 month: baseline period Dec 2011 – Oct 2012, reporting period Dec 2012 – Oct 2013. That allows pre-post comparisons based on the analysis of the evolution of the consumption figures resp. the in tenant surveys reported behaviour patterns/attitudes before and after the implementation of the service.

The following table shows the number of dwellings related to both experimental setups:

Table 4.3.1: Basic population of dwellings in the two experimental setups

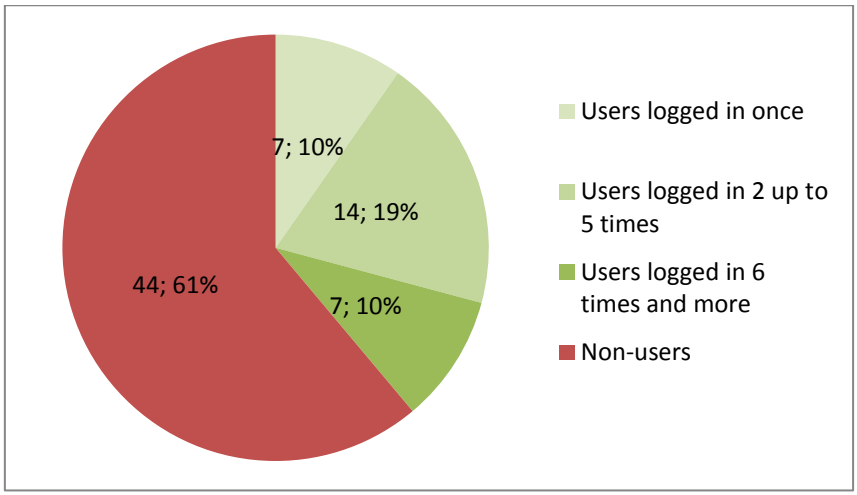
Group Status	Jabůrkové	Uzavřená	Total
Experimental group RUAS (heating)	x	x	72
Experimental group RUAS (cold and hot water)	x		
Dwellings with measurements	36	36	72

The tenant recruitment started directly after the realisation of the baseline survey in which the tenant web portal was presented and shortly explained. In addition to that, further trainings and a user guide were provided. Shortly before the service operation started the tenants received their passwords and the link to the portal (by postal and e-mail). The RUAS introduction and use were supported by several materials for tenants' motivation such as posters in the building entrance and regular reports with energy saving tips (for further details see D5.2).

[31] For the purpose of impact evaluation it was originally planned to have an approximated control group for hot water and cold water as a consequence of the both different RUAS setups. Due to technical problems it was not possible to follow that approach because of the absence of (dwelling-wise) water data in Uzavřená.

Tenants who were interested in the RUAS and that's why logged in the web portal were counted as users. Those who didn't log in were counted as non-users. The analysis of the portal log-ins showed that 28 of the total number of 72 tenants (39%) used the RUAS more or less regularly – in a range from once up to 20 times in the observed 11 month reporting period. The average portal use frequency was 4.7 times.[32]

Figure 4.3.2: Number of RUAS users and non-users



4.3.2 Results of consumption analysis

In Havirov the heat energy and cold/ hot water consumption was measured at a dwelling-wise level on a monthly basis.

Table 4.3.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	dwelling-wise
Hot water	m^3	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. In doing so, between 78% (cold water) and 88% (heat energy) of the dwellings could be included in the study.

Table 4.3.3: Overview of the number of buildings and dwellings involved in the Havirov pilot analysis

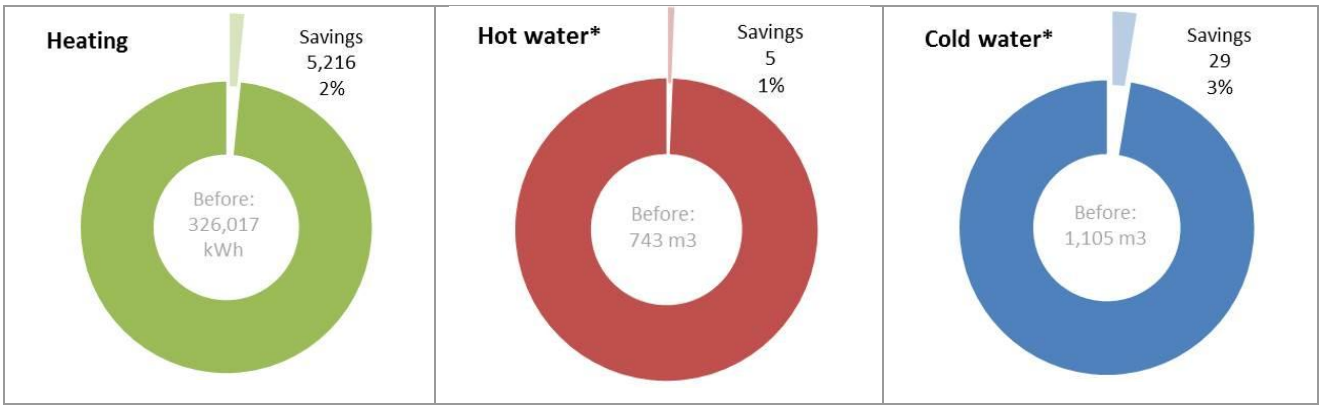
Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Havirov	2	72 (heating) 36 (water)	Heating: 63 Hot water: 30 Cold water: 28	Heating: 9 (12%; change of tenancy) Hot water: 6 (17%; change of tenancy: 5, missing values: 1) Cold water: 8 (22%; change of tenancy: 5, missing values: 3)

[32] Related to one household 313 logins have been counted. That household is not included in the calculation of the mean value.

Global results

The calculation of global savings following a pre-post comparison led to the results shown in the following figure. The tenants saved in total more than 5 thousands kWh heat energy (n=63), 29 cubic meter cold water (n=28) and 5 cubic meter hot water (n=30).

Figure 4.3.3: Overview of global results of the experimental group in Havirov



* Related to hot and cold water a sub-group of the experimental group could make use of RUAS

Compared to the target setting of 5% heat energy savings and 20% water savings, the achieved results shows a first positive trend which should be improved by consequently intensifying the target-group specific user approach. That is especially promising because the detailed results below will show that RUAS users achieved hot water savings of 8% on average. They could decrease their average water consumptions per person by 1.5 m^3 hot water resp. by 2 m^3 cold water, while the non-users had a slight increase resp. a smaller reduction. Related to heating, users as well as non-users had average savings on a small level.

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

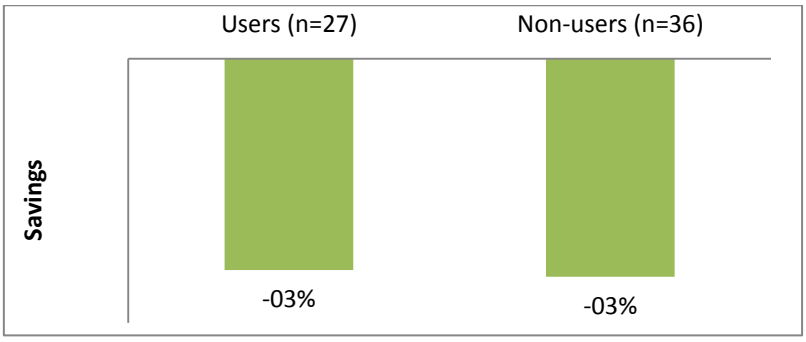
Table 4.3.4: Overview of global CO_2- and cost savings of the experimental group in Havirov

Energy /resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy	0.315 kg CO_2/kWh	1643	0.07 €/ kWh	386
Hot water	n/a	n/a	9.10 €/m^3	45.5
Cold water	n/a	n/a	2.60 €/m^3	75.4
Total		**1,643**		**507**

Heating

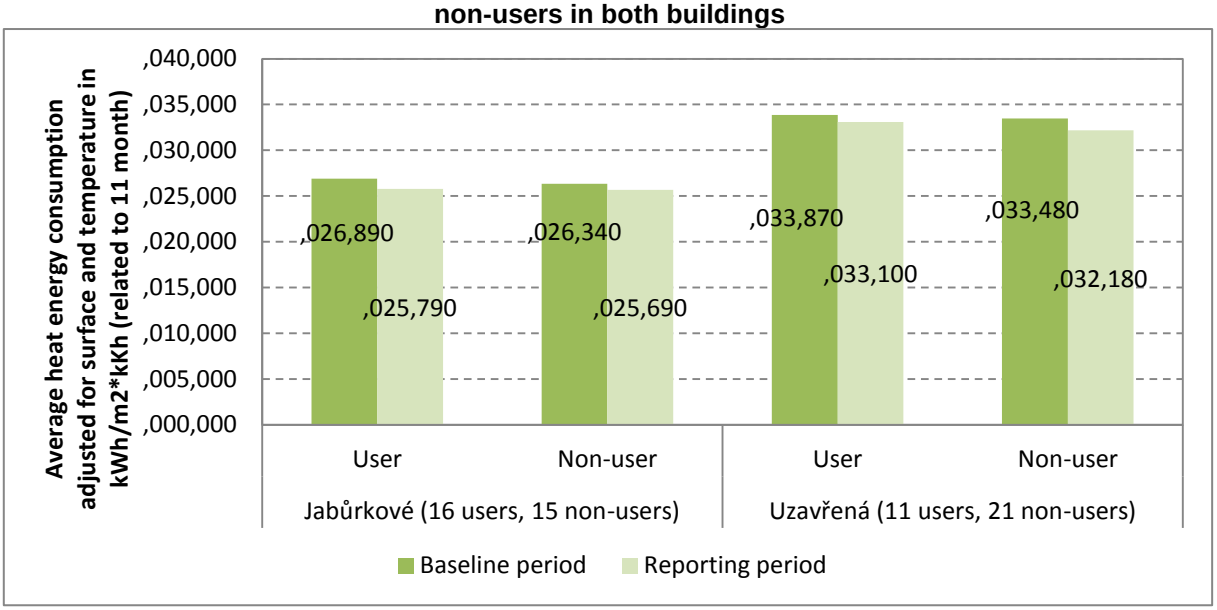
The following figure shows that users as well as non-users achieved average heat energy savings on a similar level. The deviation to the global savings of 2% above is again caused by the divergent calculation models.

Figure 4.3.4: Percentage change in heating consumption related to RUAS users and non-users



That positive result is relevant for both buildings, even though both pilot buildings seem to have divergent heating demand (see following figure).

Figure 4.3.5: Average adjusted heat energy consumption in kWh/m²*kKh related to RUAS users and non-users in both buildings



However, dwellings sizes and household sizes are very similar in both compared buildings.

Table 4.3.5: Dwelling size and household size in both pilot buildings

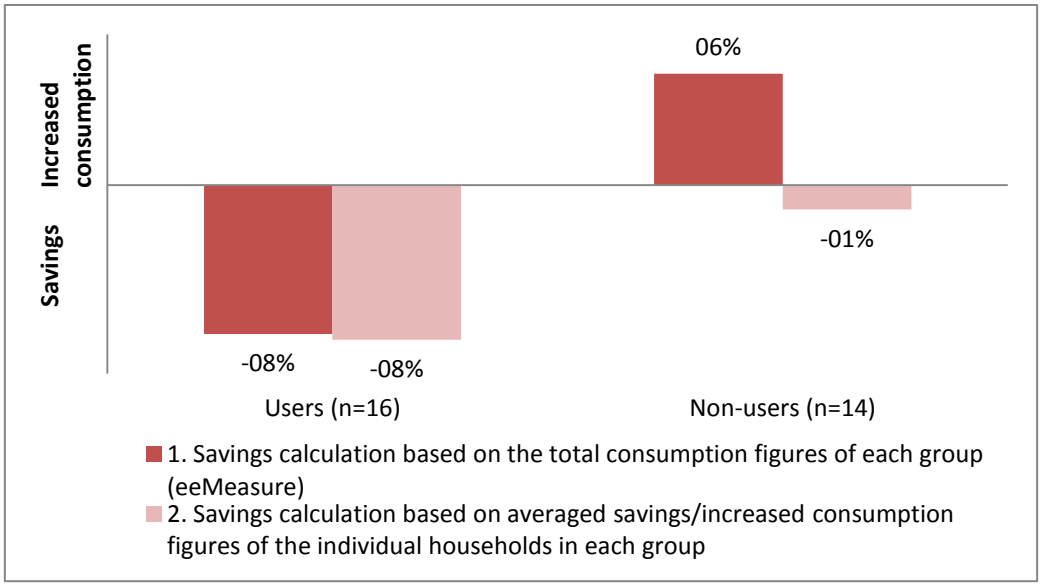
Building	Dwelling size			Average household size
	Minimum	Maximum	Average	
Jabůrkové (n=31)	21	81	56.9	2.03
Uzavřená (n=32)	24	80	56.5	2.06

In total 57 households achieved savings. Six households (three RUAS users and three non-users) had an increase of 2.6% on average.

Hot water

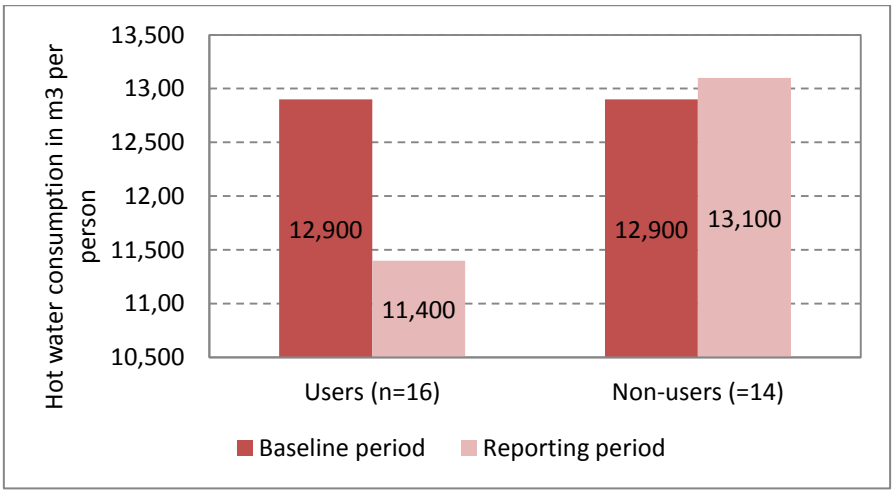
Whatever the used calculation approach is (see following figure; an explanation for these differences is described below again), RUAS users achieved better saving results related to hot water consumption than non-users – but with the addition that the difference between both groups is statistically not significant[33].

Figure 4.3.6: Percentage change in hot water consumption related to RUAS users and non-users[34]



Starting at a comparable level of approx. 13 m^3 per person on average in both groups (related to 11 month observation periods), RUAS users reduced their hot water consumption by 1.5 m^3 per person on average. In contrast, the hot water consumption of the non-users slightly increased on average in the same observation period.

Figure 4.3.7: Hot water consumption in m^3 per person related to RUAS users and non-users



81% of the RUAS users achieved savings. On average these households reduced their hot water consumption by nearly 12%. In the group of the non-users only every second household achieved savings.

[33] Analysed by t-test related to the individual savings in both groups

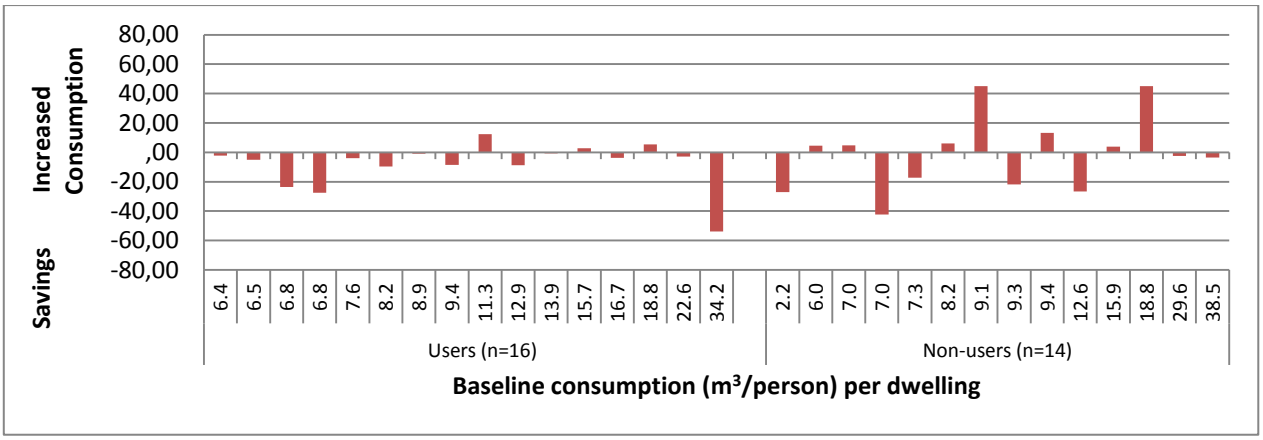
[34] The deviation to the global savings above is again caused by the divergent calculation models.

Table 4.3.6: Percentage of dwellings with hot water savings/increased consumption and correspondent average figures related to the experimental group with users and non-users

	Users	Non-users	Exp. Group in total
Absolute number and percentage of dwellings with savings	13 (81%)	7 (50%)	20 (67%)
Average savings of dwellings with savings	-11.6	-20.1	-14.6
Absolute number and percentage of dwellings with increased consumption	3 (19%)	7 (50%)	10 (33%)
Average increased consumption of dwellings with increased consumption	+6.8	+17.5	+14.3

That difference is again the reason for the divergence between both calculation models (cp. figure 4.3.6). The absolute consumption increase of a few non-users carried weight in calculation model 1, but on a percentage level (calculation model 2) their increases have been relativized by percentage savings of other non-users based on low measured baseline data. Nevertheless, the measured consumption values seem to be realistic. That's why these cases were not excluded from analysis.

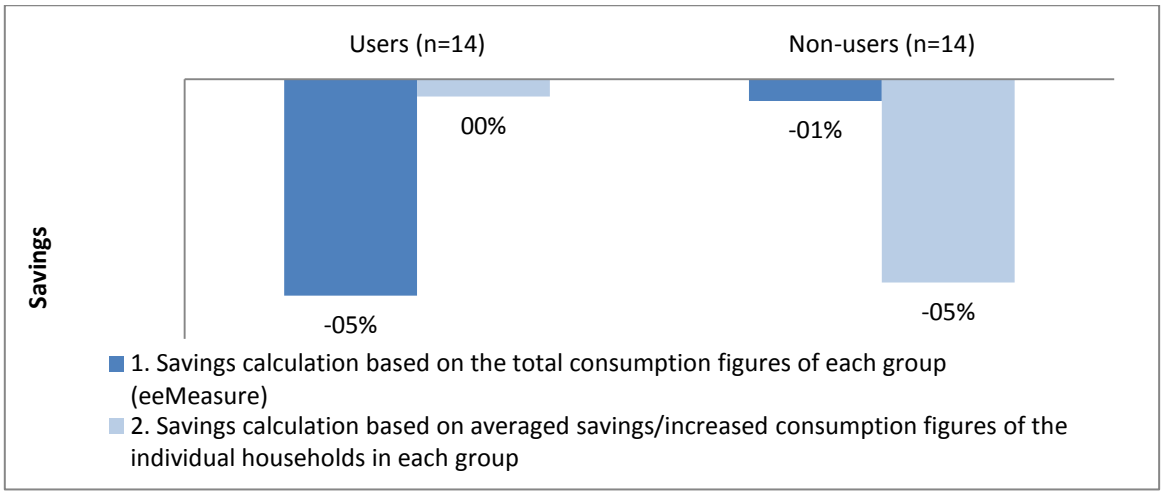
Figure 4.3.8: Savings resp. increased consumption per household (in %) related to the baseline hot water consumption (in m^3/person)



Cold water

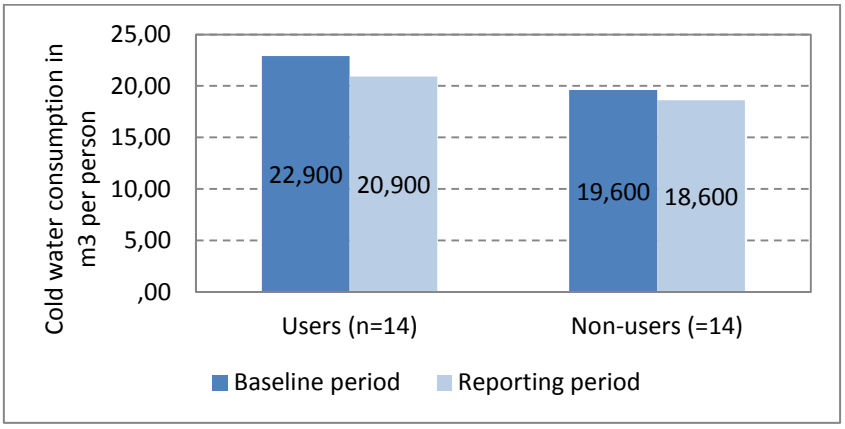
Related to cold water consumption both calculation models result in divergent saving values again (for further explanation see below). Nevertheless, there became a saving trend in both comparison groups obvious.

Figure 4.3.9: Percentage change in cold water consumption related to RUAS users and non-users



Focussing on the change in cold water consumption per person, RUAS users reduced their average cold water consumption per capita by 2 m^3 in the observation period. The non-users had a smaller decrease of 1 m^3 per person on average.

Figure 4.3.10: Cold water consumption in m^3 per person related to RUAS users and non-users



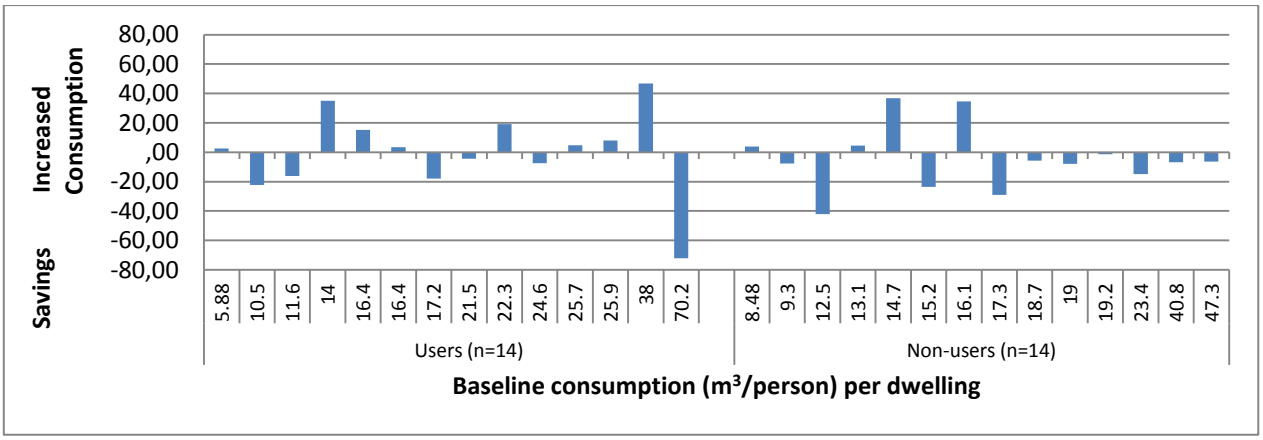
The above shown divergences in both used calculation models can be explained by the imbalance of users and non-users in the following table as well as in the following figure: A comparably larger number of non-users achieved individual percentage savings which dominate the result of calculation model 2. But the savings in absolute figures were higher in the user group than in the non-user group, which can explain the better average result of the users taking model 1 as calculation basis.

Table 4.3.7: Percentage of dwellings with cold water savings/increased consumption and correspondent average figures related to the experimental group with users and non-users

	Users	Non-users	Exp. Group in total
Absolute number and percentage of dwellings with savings	6 (43%)	10 (71%)	16 (57%)
Average savings of dwellings with savings	-23.4	-14.5	-17.9%
Absolute number and percentage of dwellings with increased consumption	8 (57%)	4 (29%)	12 (43%)
Average increased consumption of dwellings with increased consumption	+16.9	+19.9	+17.9%

Nevertheless, the measured consumption values seem to be realistic. That's why these cases were not excluded from an analysis.

Figure 4.3.11: Savings resp. increased consumption per household (in %) related to the baseline cold water consumption (in m^3/person)



4.3.3 Results of survey analysis

Results of mid-term survey

In Havirov, the mid-term survey was conducted with ten tenants in April 2013.

All respondents managed the portal log-in procedure and the navigation related to the data visualisation well - without any problems. The portal was assessed as easy to understandable and easy to handle. The respondents reported on an increased knowledge they gained from the information provided – e.g. indoor temperatures of their apartments and frequently updated water consumption data. One tenant underlined the variety of new information provided in the portal.

Regarding open issues or problems occurred when using the service, the most frequently asked question dealt with the placement of the temperature sensor at 20 cm below ceiling where the room temperature is approx. 1°C higher than on the floor. According to experts, the reasons for that commonly unusual placement are an intended minimal influence of the opposite window/ventilation and an as best as possible undisturbing location. Three tenants reported that they do not need to heat because they have already an indoor temperature which is higher than the recommended 21°C. That is very likely due to heat flows between several dwellings. On the other hand, two elderly respondents mentioned that especially old people need a higher quantity of heat than 21°C which is too cold for them and may cause health problems. This shows the different needs of different tenant groups.

The tenants had no suggestions what they would like to modify in the portal and they think that the project motivates them to save energy. They already began to implement the saving tips related to water and energy consumption in their daily routine. One respondent, for example, started to turn off the thermostatic valve when opening the window because its temperature regulating functionality was new information for her. The tenants like the monthly paper reports as useful information – also due to the fact that some tenants do not have an internet access.

Data basis and profile of respondents at baseline and final survey

The following table shows the number of respondents related to the survey stages. In the baseline survey participated 63% of the invited tenants (45 tenants), in the final survey the response rate was a little lower with 50% (36 tenants). There are 30 tenants who have participated in both panel stages and that's why will be included in the pre-post comparisons. Thereof 14 tenants belong to the group with available information on heat energy only (RUAS HE only). 16 tenants belong to the group with all resources included (RUAS HE, CW, HW).

Table 4.3.8: Number of respondents per survey stage

Participation in survey stage	RUAS Group		Total
	RUAS (HE, CW, HW)	RUAS (HE only)*	
Only baseline survey	11	4	15
Only final survey	2	4	6
baseline and final survey	16	14	30
Total	29	22	51

* control group related to water

Except the different mean age, table 4.3.9 shows that there are no further basic socio-demographic differences in both RUAS groups. Tenants who participated in both survey stages and were provided with heating information only were older than tenants of the other tenant group. Minor differences exist for the level of education and the duration of absence of all household members from their homes. So tenants who are provided with RUAS covering all resources have a slightly higher level of education and show somewhat longer durations of absence from their homes than the other group. However, there should be no limitation on the impact analyses as these differences are not as large.

Table 4.3.9: Profile of respondents in relation of survey participation

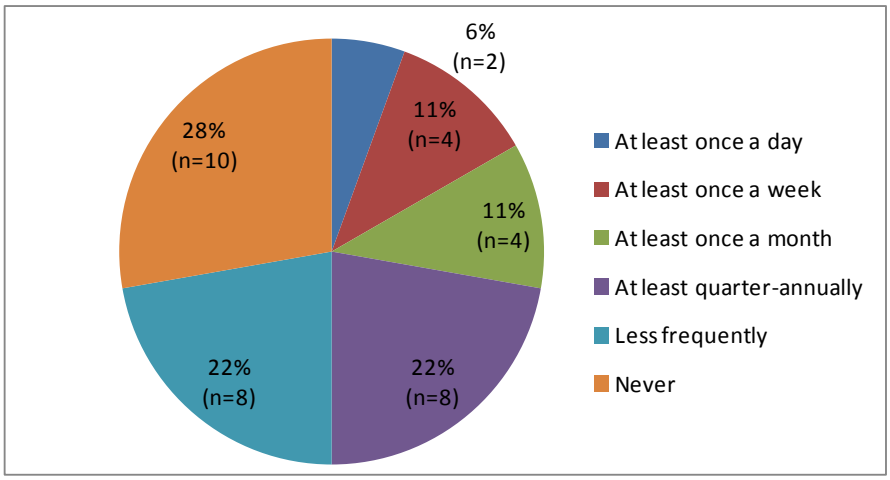
Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		RUAS (HE, CW, HW)	RUAS (HE)	RUAS (HE, CW, HW)	RUAS (HE)
Sex	Male	8 (44%)	8 (44%)	6 (38%)	4 (29%)
	Female	10 (56%)	10 (56%)	10 (63%)	10 (71%)
Country of birth	Czech Republic	18 (100%)	17 (94%)	15 (94%)	14 (100%)
	Other	0 0%	1 (6%)	1 (6%)	0 (0%)
Age	Mean	51	56	49	59
	Median	53	57	49	63
Level of education	No school leaving qualification	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Primary/secondary school leaving qualification	1 (6%)	3 (17%)	1 (6%)	3 (21%)
	Secondary school leaving qualification	10 (56%)	10 (56%)	9 (56%)	8 (57%)
	University entrance qualification	4 (22%)	4 (22%)	4 (25%)	2 (14%)
	University/university of applied science degree	3 (17%)	1 (6%)	2 (13%)	1 (7%)
Size of household	Median (persons)	2	2	2	2
Absence of all household members at normal week day	0-2 hours	3 (20%)	3 (20%)	1 (8%)	3 (25%)
	3-5 hours	3 (20%)	4 (27%)	3 (23%)	4 (33%)
	6-8 hours	3 (20%)	1 (7%)	3 (23%)	1 (8%)
	More than 8 hours	6 (40%)	7 (47%)	6 (46%)	4 (33%)
Rent or service Charges paid by municipality	No	15 (100%)	13 (81%)	14 (100%)	11 (79%)
	Rent and all services charges	0 (0%)	2 (13%)	0 (0%)	2 (14%)
	Rent	0 (0%)	1 (6%)	0 (0%)	1 (7%)

RUAS use and motivation of tenants

All tenants of the experimental group have already heard from the tenant portal. Nearly three quarter of the tenants are registered portal users (26 out of 36 tenants), but eight of them are not

considered as active users because they did not log in regularly (semi-annually or less frequently). That equates to a proportion of 50% (18 tenants) who are treated as active portal users. Most of them (10 tenants) logged in often – from at least once a month up to a very high use frequency with at least one daily log-in. The remaining eight respondents logged in at least quarter-annually. These active users are uniformly distributed in both RUAS setups – nine persons in each group.

Figure 4.3.12: Frequency of portal use (n=36; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

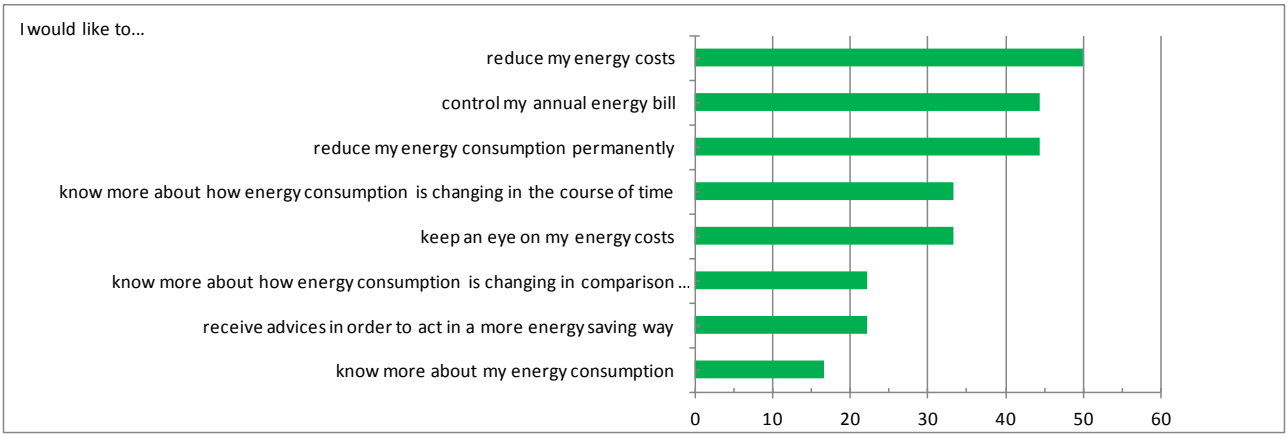
Before starting the RUAS services, the motivation to save energy consists predominantly in saving money and protecting the environment equally (60% or 18 out of 30 tenants). This is also true when analysing both RUAS groups separately. Among the tenants with another opinion, motivations towards saving money are more frequent. So 27% of all tenants state that saving money has a higher influence on motivation than protecting the environment, 10% state that their motivation consists solely in saving money. On the other hand there is only one person who is motivated more by the protection of the environment than by saving money.

After the use of the tenant portal, still both motivational aspects equally are the predominant motive of most of the tenants, but their proportion declined to 53%. For 23% (7 out of 30 tenants) it is more important to save money than to protect the environment. At the same time there is a very small shift towards the protection of the environment obvious which is stated by 13% of the tenants (to protect the environment is more important than to save money).

Reasons for using and for not using the tenant portal

Among the 18 tenants who are using the tenant portal actively and who have participated in the final survey, the reduction of energy costs is the most important reason for using the tenant portal (50% of tenants strongly agree). The control of the energy bill and the permanent reduction of energy consumption are reported from 44% of the tenants (8 out of 18) in each case. To know more about how the energy consumption is changing over time and to keep an eye on the energy costs is for 22% of the tenants an important reason. The other motives asked for are of minor interest of the tenants.

Figure 4.3.13: Reasons for using the tenant portal
(n=18; active users; percentages for "I strongly agree")



Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

The 14 tenants who are not active portal users have been asked for the reasons for non-using. Among the most important reasons (based on designation of "I strongly agree") there are aspects related to the medium internet and related to opinion that the portal cannot provide additional information. Five out of 14 tenants strongly agree that the annual energy bill is sufficient. Four respondents prefer information on paper. Three tenants think that they are already well grounded in energy issues and don't need further information. Two tenants don't have a permanent internet access. This result shows that parts of these tenants are very likely reading the paper reports that have been provided to the tenants additionally.

The following analyses of the RUAS service impacts on ecological awareness and behaviour are not restricted to the active portal users. So, the impact of the whole RUAS including portal as well as paper reports can be taken into account.

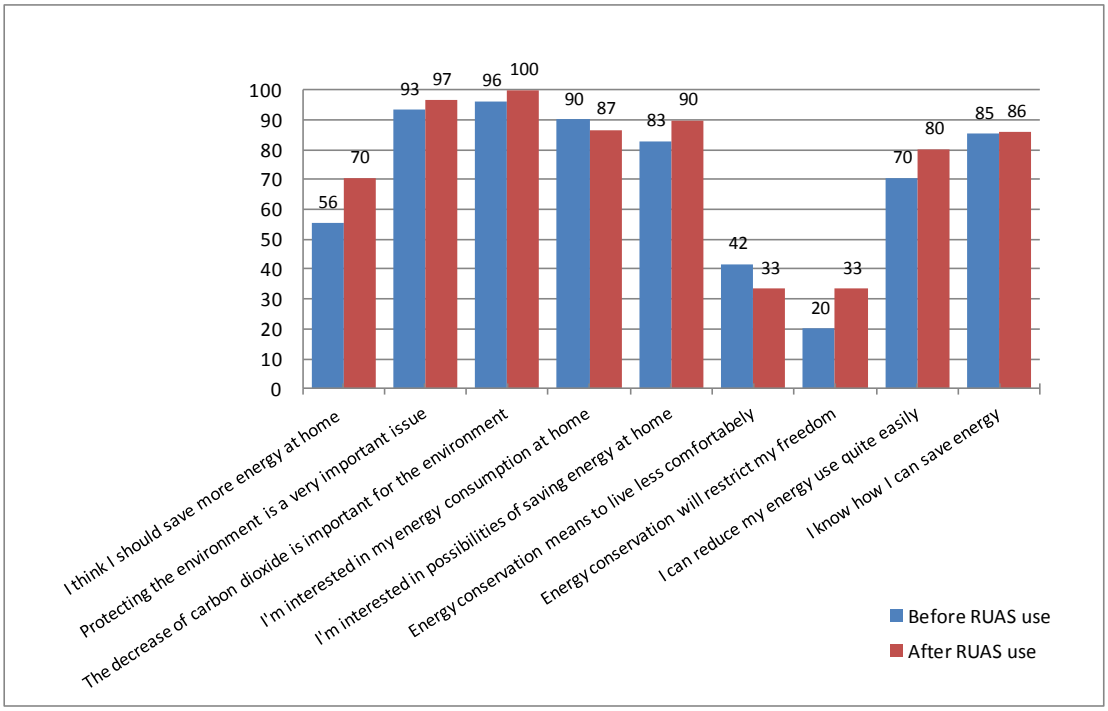
Impact on ecological awareness

Figure 4.3.14 shows the ecological awareness before and after the RUAS use related to the tenants of both experimental groups together. It becomes obvious that already prior the use of RUAS there is a high level of ecological awareness. However, this level rises again after the use of RUAS for almost all aspects.

The greatest development is related to the subjective energy saving norm which means the opinion that the tenant himself should save more energy at home – an opinion with a relatively low basis level prior the portal use, but a difference of about 15%-points shown in the pre-post comparison. At the same time the interest in possibilities of saving energy at home raises by about 7% and the opinion that one's energy use can be reduced quite easily raises about 10%. In addition to that, the opinion that energy conservation means to live less comfortably decreases by 8% (from 42 to 33%) which also shows a positive influence of the portal use. The positive trends related to the other aspects are smaller (up to 4%-points), but these items had already a very high basis level (more than 90% positive statements in the baseline survey).

However, there are only two statements showing a negative trend. This is mainly true for the opinion that energy conservation will restrict ones freedom that is stated from one third of the tenants in the final survey, but only from one fifth at the baseline stage (difference of 13%-points). The other statement is related to the personal interest in energy consumption at home with more or less unchanged response behaviour, but on still high agreement level (small negative trend of 3%).

Figure 4.3.14: Ecological awareness of experimental group tenants before and after RUAS use
(n=24-30 due to missing values); percentages for answer categories “strongly agree and rather agree”)



Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don’t know.

When comparing the mean values of the statements by carrying out a t-test, the positive picture is confirmed (see Table 4.3.10). For all statements there can either be found a positive trend or no differences occur. The strongest trend exists in the personal belief that the reduction of the own energy use is quite easy. There a statistically significant difference became obvious. However, the test confirms that at the final stage more tenants

- are interested in the possibilities of saving energy at home
- are interested in their energy consumption
- think that they should save more energy at home (have a high energy saving norm)
- know how they can save energy

At the same time fewer tenants are of the opinion that energy conservation means to live less comfortably.

These results suggest a meaningful impact of the RUAS. Though there is no control group available these results cannot be proved against further influences besides the RUAS services.

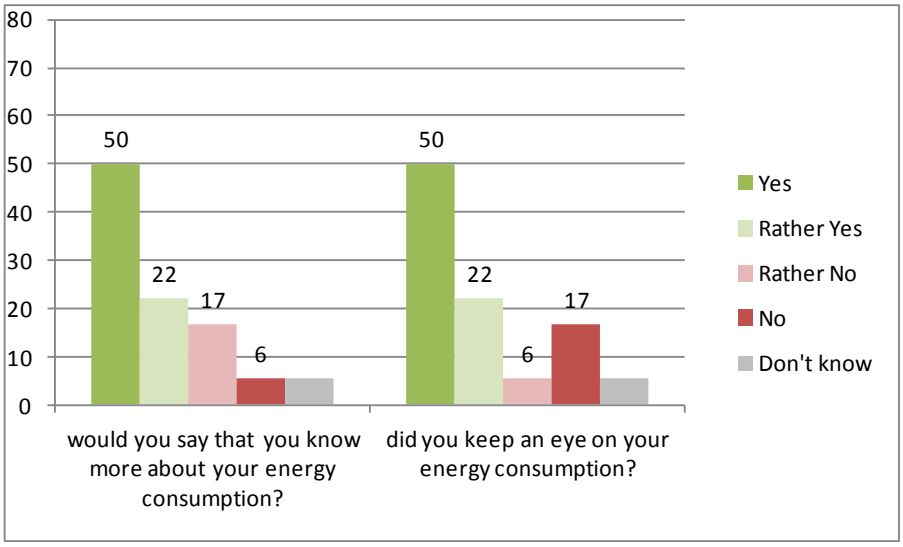
Table 4.3.10: Pre-post comparisons of ecological awareness

Statement	Experimental group		
	baseline (mean)	final (mean)	pre-post comp.[1] (mean diff.)
I think I should save more energy at home	2.5	2.4	0.2
Protecting the environment is a very important issue	1.3	1.3	0.0
The decrease of carbon dioxide is important for the environment	1.2	1.2	0.0
I'm interested in my energy consumption at home	1.7	1.5	0.2
I'm interested in possibilities of saving energy at home	1.9	1.5	0.4
Energy conservation means to live less comfortably	3.0	3.5	-0.4
Energy conservation will restrict my freedom	3.7	3.7	0.0
I can reduce my energy use quite easily	2.7	1.9	0.8*
I know how I can save energy	1.9	1.7	0.1

[1] A positive value means a trend towards pro-ecological awareness with exception of the statements: “Energy conservation means to live less comfortably”, “Energy conservation will restrict my freedom”.
* The difference is statistically significant at p<0.05.

The retrospective view of the respondents on the influences of the tenant portal on their knowledge and behaviour is also mainly positive. Half of the 18 active users think that they now know more about their energy consumption and that they keep an eye on it. Further 22% rather agree. On the other hand only small percentages state that they (rather) do not agree with the statements.

Figure 4.3.15: Knowledge and relevance of energy saving issues resulting from RUAS use
(n=18; percentages)



Question: Thinking of the provided tenant portal…
- would you say that you know more about your energy consumption?
- did you keep an eye on your energy consumption?
Answer categories: “Yes”, “Rather yes”, “No”, “Don*t know”.

In summary, it can be stated that the ecological awareness and knowledge of the tenants increased during the RUAS use. This is a strong indication of the positive RUAS – even if it cannot be analysed for further (external) influences due to the absence of the control group.

Impact on ecological behaviour

The pre-post comparison of both RUAS groups together reveals very positive changes in tenants' behaviour. Related to all given statements there is a trend towards a more ecological behaviour. Related to half of the statements the proportion of tenants who strongly or rather agree is rising up to 100% or nearly 100%. These statements with high agreement level are related to heat energy saving (turn the heating down when leaving a room unused or when leaving the home for a longer time, keep shut windows in winter time), electricity consumption (turn out light when nobody is in the room, unplug chargers from the mains, switch of TV when nobody is in the room) and hot water consumption (rather take a shower instead of a bath). In addition to that, behaviour patterns that have been not very common before the portal use – such as turning off the heating when opening the windows, completely switching off appliances with stand by-function or using cold water for washing hands – are much more frequent at the final stage.

Figure 4.3.16: Ecological behaviour of experimental group tenants before and after the use of RUAS
(n=4-30 due to missings[35]; percentages for answer categories "strongly agree and rather agree")

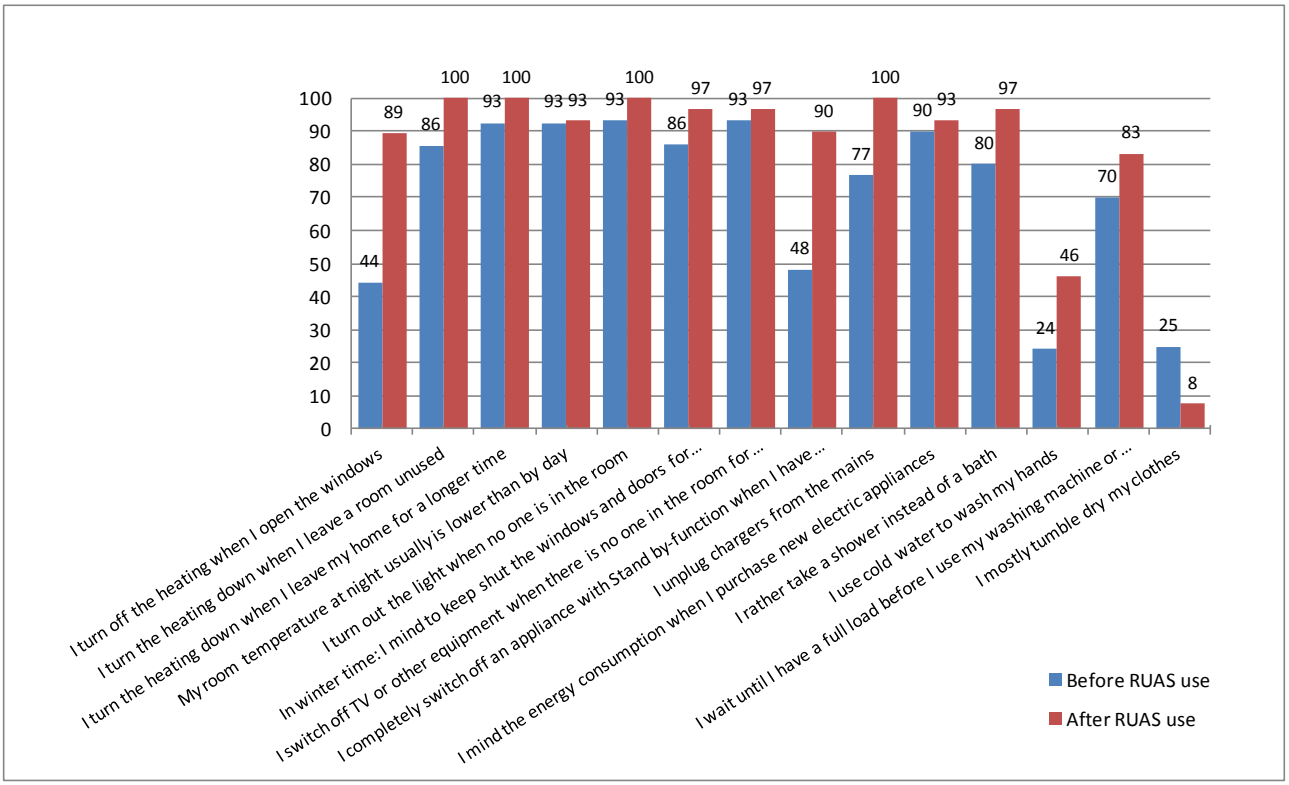


Figure 4.3.17 shows the results of the pre-post comparisons separately for each RUAS group and for both groups together.

Even if the sample sizes are quite low there became positive trends obvious which concern all kinds of behaviour in both RUAS groups.[36] At the same time the results show that the behavioural changes are not related to a single RUAS group respectively to a specific kind of services. For example, tenants who are provided with feedback solely about heat energy show also a trend

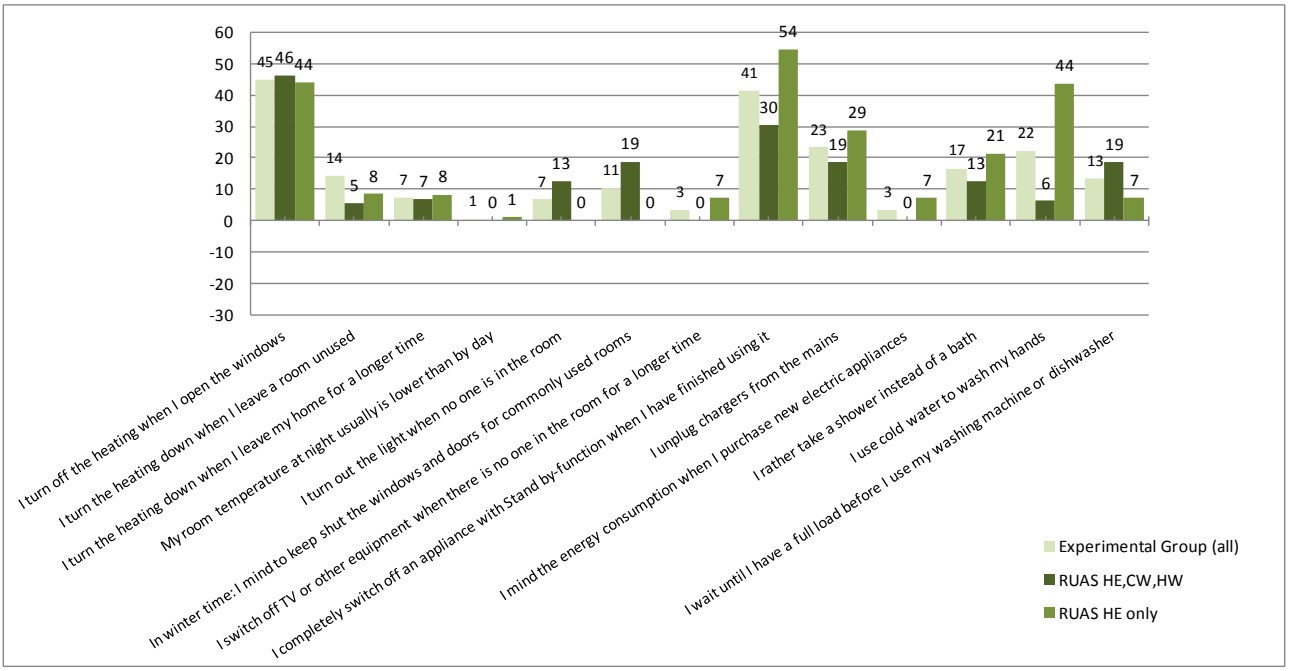
[35] Answer categories „not applicable" and "don't know" were coded as missing. The very low number of cases is caused by many tenants not having a dryer. So this statement is appropriate for 4 tenants only at baseline stage. For the other statements the number of cases is at least 17.

[36] The result for "I mostly tumble dry my clothes" is not shown in the figures as sample sizes are too low (there is only one tenant having a dryer in the RUAS HE group).

towards pro-ecological behaviour related to water consumption resp. all tenants show positive trends related to electricity consumption which is not part of that specific service.

That implies the conclusion that there are spill-over effects resulting from the fact that the ecological awareness is generally activated and therefore tenants take care also in other consumption domains within their homes. This could be due to further services around the tenant portal that are available for all tenants or due to communication with the neighbourhood (e.g. between tenants of both groups). Related to the behaviour focussing on electricity consumption, this means that they already had knowledge about what they can do in order to save energy and they are now make sure that they put this knowledge into practice. In addition to that, the questions about electricity consumption in the baseline survey might also have turned the attention of the tenants on this resource. However, it cannot be excluded that other factors than the RUAS services (e.g. information provided by the electricity provider) may play a role in that context.

Figure 4.3.17: Changes of ecological behaviour of RUAS groups (n=12-16 due to missing values[37]; pre-post comparisons; percentage point differences for answer categories "strongly agree and rather agree")



The sample sizes allow for carrying out mean value comparisons of the experimental group including both kinds of RUAS services. The results, shown in table 4.3.11., correspond with the previous descriptive analyses. The greatest changes towards a pro-ecological behaviour can be found for turning off the heating when opening the windows and for completely switching off an appliance with Stand by-function. Both mean differences are statistically significant. Therefore it can be concluded that they are not caused by chance, but mainly due to the provided RUAS service.

Furthermore, relevant behaviour changes can be found related to unplugging chargers from the mains, taking a shower instead of a bath, using cold water to wash hands and turning the heating down when leaving a room unused.

[37] Answer categories „not applicable" and "don't know" were coded as missing.

Table 4.3.11: Pre-post comparisons of ecological behaviour

Statement	Experimental group		
	baseline (mean)	final (mean)	pre-post comp.[1] (mean diff.)
I turn off the heating when I open the windows	3.2	1.6	1.6*
I turn the heating down when I leave a room unused	1.5	1.2	0.3
I turn the heating down when I leave my home for a longer time	1.3	1.2	0.1
My room temperature at night usually is lower than by day	1.4	1.5	-0.1
I turn out the light when no one is in the room	1.1	1.0	0.1
In winter time: I mind to keep shut the windows and doors for commonly used rooms	1.4	1.3	0.1
I switch off TV or other equipment when there is no one in the room for a longer time	1.3	1.3	0.1
I completely switch off an appliance with Stand by-function when I have finished using it	2.5	1.7	0.8*
I unplug chargers from the mains	1.8	1.3	0.5
I mind the energy consumption when I purchase new electric appliances	1.3	1.4	-0.1
I rather take a shower instead of a bath	1.5	1.2	0.4
I use cold water to wash my hands	3.3	2.9	0.4
I wait until I have a full load before I use my washing machine or dishwasher	2.0	1.7	0.2
I mostly tumble dry my clothes	n/a	n/a	n/a

[1] A positive value means a trend towards pro ecological behaviour (with exception of the last statement).
* The trend is statistically significant at p<0.05.

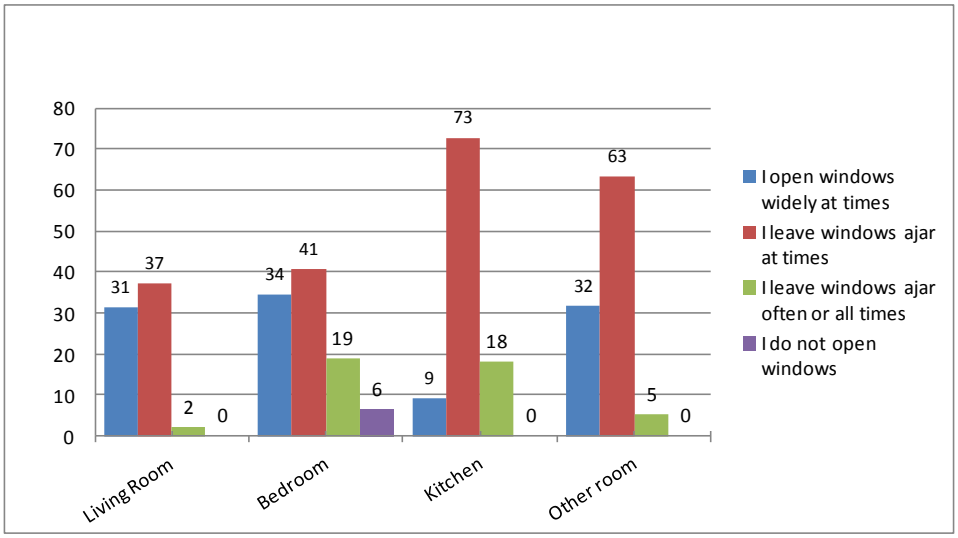
Ventilation behaviour

Figure 4.3.18 illustrates the ventilation behaviour of all respondents of the final survey.[38] As shown most tenants are showing pro-ecological ventilation behaviour. The two recommended ways of ventilating rooms (open windows widely at times as best option and leave windows ajar at times as second best option) are realised by nearly all tenants in living rooms and other rooms. Related to bedrooms and kitchens, more than three quarters follow that recommendation. To leave windows ajar often or all times, which is the most unfavourable ventilation option, is realised by a few tenants only and is especially applied to bedrooms (very likely night ventilation) and kitchens (6 persons in each case).

Nevertheless, the question regarding the duration of leaving windows ajar shows that the majority of the tenants do that at least one hour a day (56%). This shows some remaining potential for improvements by reducing the duration of ventilation or by open windows widely at times instead of tilt ventilation.

[38] A pre-post comparison is not possible as the question was modified in the final survey.

Figure 4.3.18: Ventilation behaviour of experimental group tenants in winter time (final stage)
(n=19-36 due to missings[39]; percentage)



Room temperature

Considering the room temperature in winter there can be found quite high temperatures. Prior the use of the tenant portal in much used rooms the temperature ranges between 20 and 26°C and is 23°C on average. These reported temperatures stayed more or less constantly, but it has to be noted that quite a lot tenants don't know their room temperature and that's why these analyses base on rather small sample sizes. This is especially true for little used rooms, which makes an analysis impossibly because of only three tenants with statements at baseline stage. However, at final stage more tenants were informed about their indoor temperatures than at the baseline stage. That means that their consciousness rose during the use of the portal (from 17 to 26 respondents with regard to much used rooms, from 3 to 12 persons regarding little used rooms).

Retrospective and prospective behaviour

The retrospective view on the tenants' behaviour also shows a positive influence of the tenant portal. Among the 18 active users 44% state that they have changed their energy consumption behaviour as a result of using the portal. One third is not decided. Only 22% (4 tenants) denies behavioural changes.

In parallel, 61% of the active users intend to conserve heat energy, electricity and water in future. Further 28% are quite sure to intend to save energy in these fields. On the other hand, only one person very likely does not have that intention while another person is undecided yet.

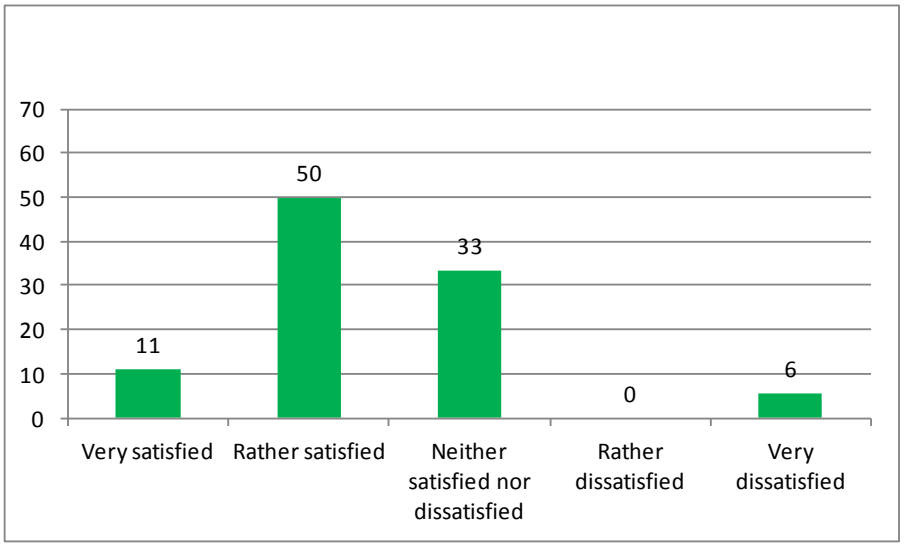
In summary, the RUAS services show a positive influence on the tenants' behaviour. That applies to a lot of the observed domains. The tenants behave now in a much more ecological way even if it cannot be completely excluded from a statistical point of view that some of these positive developments could also be caused by further factors.

[39] Answer category „not applicable/no window in room" was coded as missing.

Satisfaction with tenant portal

The general satisfaction with the tenant portal is high. 61% of the active portal users state that they are very or rather satisfied (11 tenants) whereas 33% are not decided (6 tenants). However, there is only one very dissatisfied person. Despite this positive judgment, to tenants' mind there is still some improvement possible.

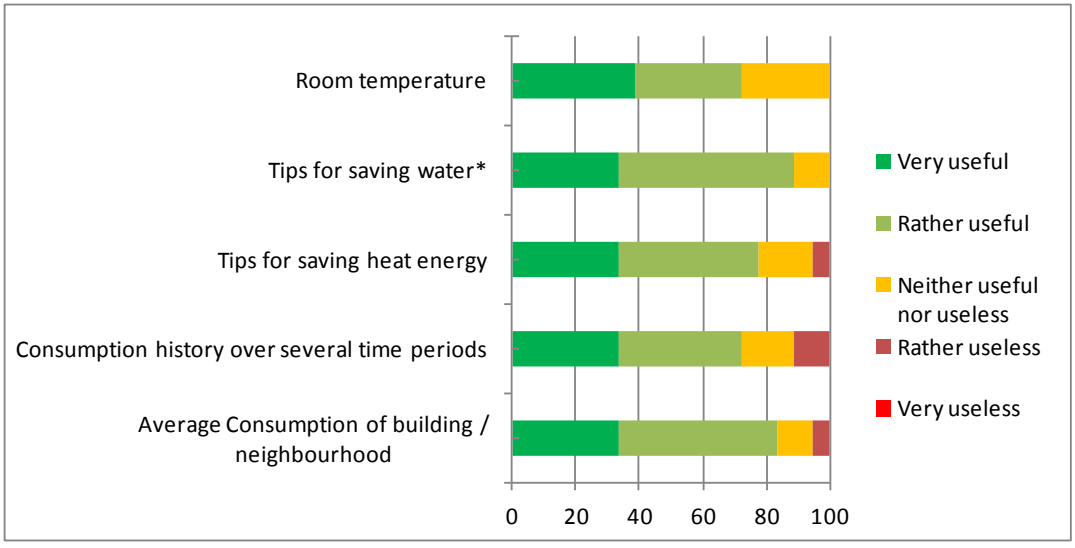
Figure 4.3.19: General satisfaction with tenant portal
(n=18; percentage)



Question: How satisfied are you with the services of the tenant portal in general?

The opinions related to the usefulness of different information presented in the tenant portal are shown in the following figure. It becomes obvious that all information is considered as useful. Based on the answer category "very useful", the room temperature is assessed as most useful information (39%). When looking on the category "rather useful" tips for saving heat energy and the average consumption of the building or the neighbourhood range at first position. Tips for saving water are also appreciated by the tenants, but as this result bases on the sub sample of RUAS (HE, CW, HW) it can be hardly compared with the other aspects.

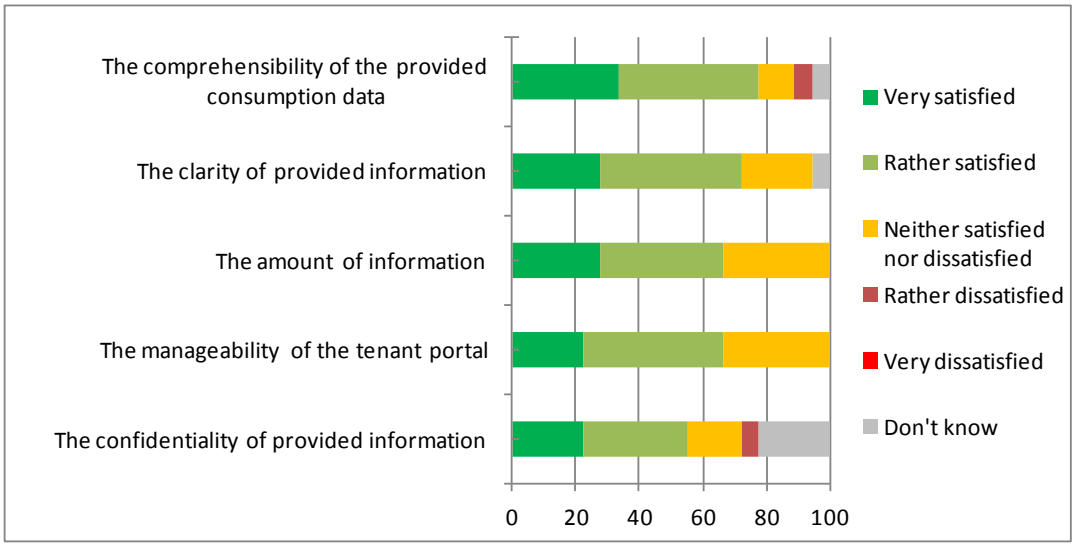
Figure 4.3.20: Usefulness of information presented in the tenant portal
(n=18; percentage)



* The proportions are based on the subsample of tenants receiving RUAS for HE, CW and HW (n=9).

The handling of the tenant portal is considered as satisfactory. The majority of the active users are very or rather satisfied with four of the five aspects. The highest agreement with the answer category “very satisfied” are related to the comprehensibility of the provided consumption data (33%), followed by the clarity of the provided information and the amount of information (28% each). It becomes also obvious that most aspects could be improved from the perspective of the tenants. This is shown by the rather high percentages of the answer “Neither satisfied nor dissatisfied” which is especially true for the amount of information and the manageability of the tenant portal. In addition to that, one fifth of the tenants do not know how much they are satisfied with confidentiality issues. This means that referring to this point more efforts on persuasion could help to strengthen the belief in the tenant portal and its information.

Figure 4.3.21: Satisfaction with handling of the tenant portal
(n=18; percentage)



Prospective portal use and willingness to pay

More than half of the active users intend to use the tenant portal frequently in future (10 out of 18). Five tenants do not intend to continue the portal use. Further three tenants link their use intention to further improvements of the portal. For example, one of these three persons would like to have the meters placed on the radiators. The other two persons do not specify their suggestions for improvements.

All ten tenants who intend to use the portal in future are not willing to purchase an energy monitoring device that is comparable to the tenant portal.

In summary, the active users are satisfied with the tenant portal even if there are some aspects that could be improved from the perspective of the tenants. Primarily, the clarity and comprehensibility of the provided information is judged as satisfactory.

4.3.4 Results of combined analysis

In Havirov the combined analysis of survey data and consumption data includes heat energy, cold water and hot water consumption. It is examined whether the ecological awareness of tenants and their ecological behaviour is related to their energy consumption and savings they have achieved during the project or not.

Subjective energy saving norm and energy consumption

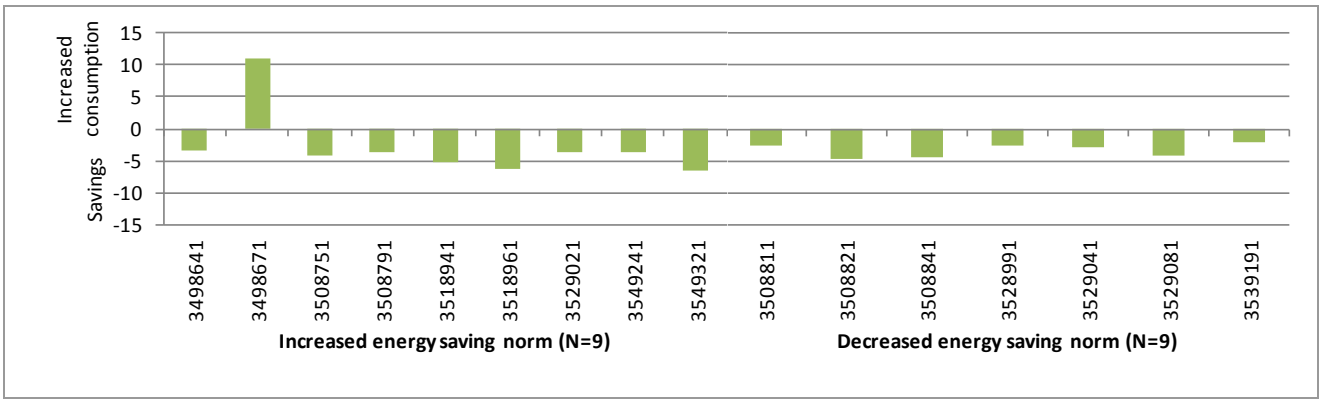
The following analysis examines the relation between the subjective energy saving norm ("I think I should save more energy at home") and the savings achieved by the tenants. The focus is on the question whether tenants with increased energy saving norm during the project show higher savings than tenants with decreased or constant energy saving norm.

In the baseline survey the majority of tenants who participated in both survey stages reported on a (rather) high energy saving norm (44% rather agree, 4% strongly agree). 19% neither agreed nor disagreed, 22% disagreed. Only one tenant strongly disagreed with that item. In the final survey there became a slight trend obvious towards a higher energy saving norm. Now 71% of the respondents (rather) agree with that item (52% rather agree, 19% strongly). At the same time there are fewer tenants with lower energy saving norms.

Focussing on the individual changes of the energy saving norm, information of 24 tenants is available.[40] Thereof seven tenants show a decreased, nine tenants show an increased energy saving norm. For eight tenants it stays at a constant level. As not for all of them information about their energy consumption is available, the number of cases reduces to 23 for heat energy, 12 for cold water and 13 for hot water consumption.

With respect to heat energy, the following figure shows that the changes of the energy saving norm leads only partly to the expected results. In fact, most tenants with increased energy saving norm achieved savings which represents the expected relation. On the other hand, tenants with decreased of unchanged (not shown in the figure) energy saving norm also achieved savings. That means that the energy saving norm does not work as main driver for heat energy savings, but there seem to be other factors having a greater influence.

Figure 4.3.22: Percentage change in heat energy consumption for tenants with increased and decreased energy saving norm



With respect to hot and cold water consumption there can be found some evidence of a positive influence of an increased energy saving norm. Most tenants with increased energy saving norm show savings while most tenants with decreased energy saving norm consumed more water in the reporting period. However, also two tenants with increased energy saving norm had a water consumption increase and one tenant with decreased energy saving norm achieved small savings.

[40] Tenants with changes from or to the answer category „don't know" are excluded from the analysis.

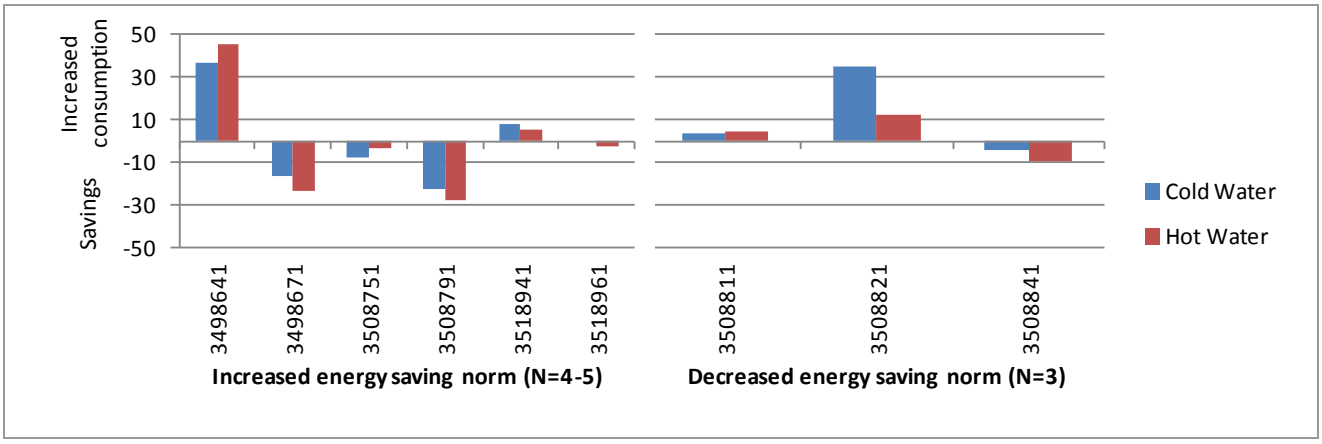
The percentage change of those tenants cannot be explained by their initial situation (e.g. very low or high water consumption in the baseline period) or by their very high/low energy saving norm.

Considering the average savings of the different groups, the influence of the energy saving norm is largely confirmed. So, tenants with increased energy saving norm saved on average 0.2% cold and 1.1% hot water. On the other hand, tenants with decreased energy saving norm have an consumption increase of 11.5% cold and 2.4% hot water.

Tenants with unchanged energy saving norm – whereas all tenants showed a rather high energy saving norm in both periods – consumed 15.7% more cold water on average, but saved 5.0% hot water. This is not really striking because in these cases the energy saving norm should not work as main driver, but other factors can do so. It is assumed that the increased consumption of cold water is partly due to savings of hot water.

As all tenants examined belong to the RUAS setup that includes heat energy, hot and cold water, the setup is not relevant for the reported changes in water consumption.

Figure 4.3.23: Percentage change in water consumption for tenants with increased and decreased energy saving norm



Everyday ecological behaviour and energy consumption

Heat energy consumption

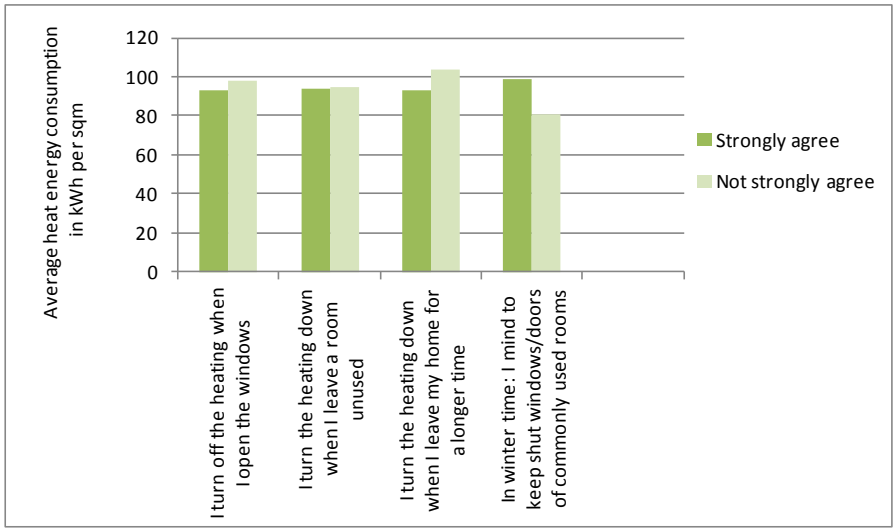
In the following section the ecological behaviour reported in the final survey is analysed with regard to the measured energy consumption during the reporting period.

The first part focuses on heat energy consumption with available information about the following activities: turning off the heating when opening windows; turning down the heating when leaving a room unused; turning down the heating when leaving the home for a longer time; mind to keep shut windows and doors of commonly used rooms in winter time.

The following figure shows for three of these activities slightly lower consumption of tenants who strongly agree with these items than of tenants who do not strongly agree.[41] The only exception represents the behavioural item “I mind to keep shut windows/rooms of commonly used rooms” because in that case tenants with a high level of ecological behaviour consume more energy than others. This result seems to be plausible as the activity refers to commonly used rooms and therefore is not directly related to the heat energy consumption in the dwelling. However, in general the differences between both groups are rather small.

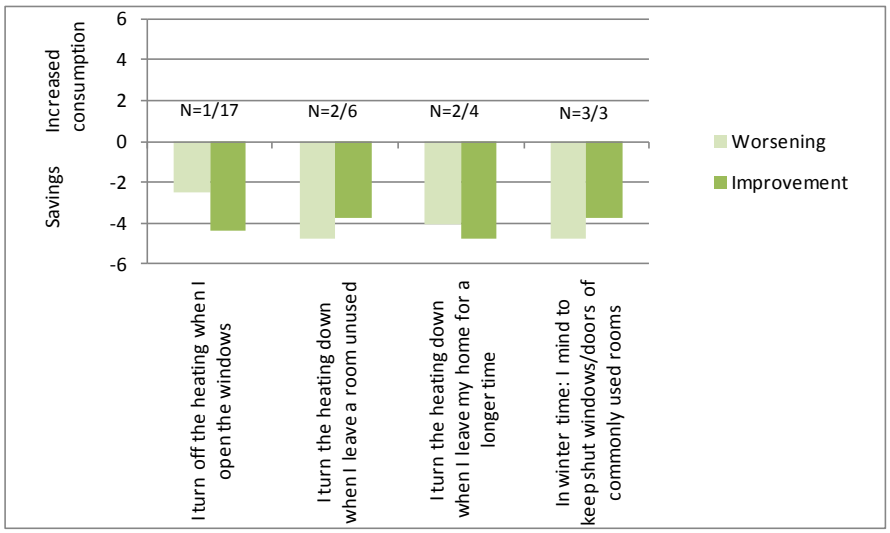
[41] This includes the following answers: I rather agree, I neither agree nor disagree, I rather disagree, I strongly disagree.

Figure 4.3.24: Heat energy consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



When analysing the changes of ecological behaviour in relation with the achieved savings/increased consumptions, different results can be found. First of all, there are savings for all subgroups and all behaviour patterns obvious.

Figure 4.3.25: Percentage change in heat energy consumption for tenants with worsened and improved ecological behaviour



With respect to the items “I turn off the heating when I open windows” and “I turn the heating down when I leave my home for a longer time”, tenants with improved ecological behaviour saved more heat energy than tenants with worsened behaviour. This indicates that both behaviour patterns are related to the amount of savings achieved.

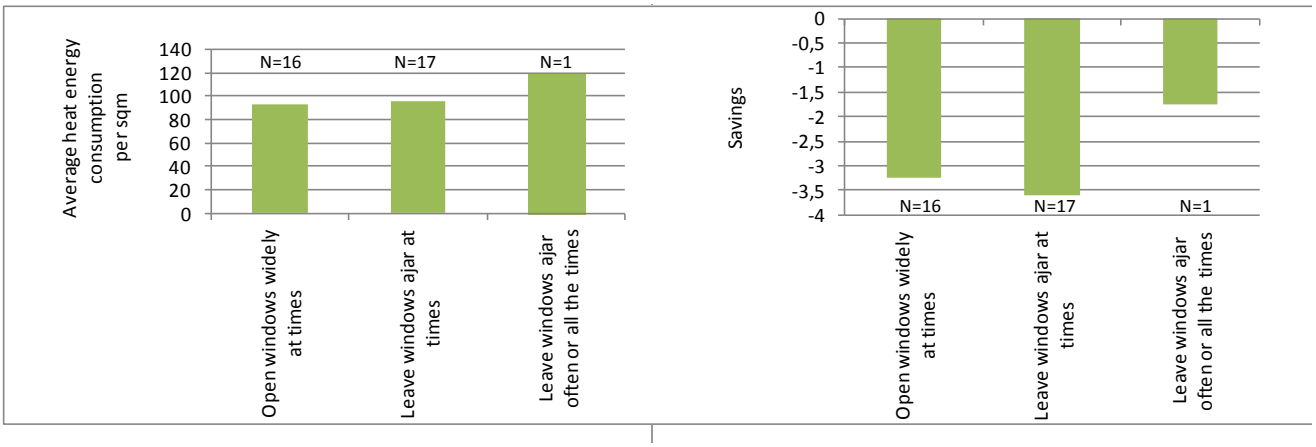
For the items “I turn the heating down when I leave my home for a longer time” and “I mind to keep shut windows and doors of commonly used rooms” opposite results are visible. These cannot be explained by the initial baseline energy consumption or the levels of ecological behaviour. But there might be interfering aspects which could be one explanation for the savings of tenants who more seldom turn the heating down when leaving their homes for a longer time at final stage (= worsened behaviour). For example, one of these two tenants shows worsened behaviour related to that item, but shows in parallel an improved behaviour related to turning off the heating when opening windows. The second tenant additionally shows improved behaviour when keeping shut windows and doors of commonly used rooms. One further explanation could be that the single

items are not relevant for all tenants equally. For example, a tenant might always turn down the heating when leaving a room unused, but in reality the tenant very seldom leaves a room unused. In this case the behaviour would carry less weight related to the energy consumed.

This shows that the relation between behaviour and energy consumption / savings is very complex. At the same time the results should not be over-interpreted due to the small number of cases.

Furthermore, the ventilation behaviour of tenants is assumed as important influencing factor on heat energy consumption resp. savings. In the final survey the tenants were asked how they usually ventilate different rooms of their dwelling in winter time or on colder days.[42] The following analysis concentrates on the ventilation of living rooms.

Figure 4.3.26: Heat energy consumption (reporting period) and percentage change related to ventilation behaviour in living rooms reported in final survey



The above figure shows that the heat energy consumption is influenced by the ventilation behaviour. So, tenants who open the windows widely at times consumed less energy than tenants who leave windows ajar at times. The tenant who leaves the windows ajar often or all the times consumed most heat energy.

The relation between ventilation behaviour and energy savings is less obvious because all tenants achieved savings. Indeed, the tenant with permanent tilt ventilation achieved the smallest savings, but tenants who leave windows ajar at times achieved somewhat more savings than tenants who open windows widely at times. A closer look reveals that this is partly due to different initial situations. So tenants who open windows widely at times consumed already less heat energy in the baseline period (89 kWh/sqm) than tenants who leave windows ajar at times (91 kWh/sqm). This means that the potential for savings is higher for tenants who prefer tilt ventilation.

A further explanation is that there is one tenant in the subgroup of tenants who open windows widely at times who has a consumption increase of 11%. This outlier leads to a bias when averaging the savings. After excluding this case from analysis, the average savings of this tenant group are higher (4.2%) – especially compared to tenants who leave windows ajar at times.

That means that an influence of the ventilation behaviour on the heat energy consumption and the achieved savings can be confirmed. Therefore, it is very useful to provide hints to the tenants concerning their ventilation behaviour as it was done in the RUAS at Havirov. However, due to the modification of that question in the final survey, it is not possible to examine the changes in consumption in relation to the changes of behaviour which would be a better way for explaining the influence of the behaviour on the achieved savings.

[42] Answer categories: “I open windows widely at times”, “I leave windows ajar at times”, “I leave windows ajar often or all the times”, “I do not open windows”, “not applicable”.

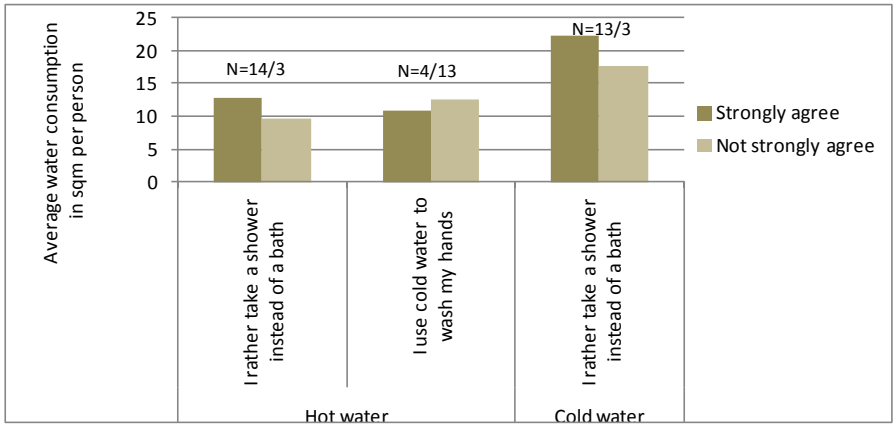
Water consumption

When focussing on water consumption, two items of the everyday consumption behaviour are relevant:

- "I rather take a shower instead of a bath" which is relevant for hot and cold water consumption and
- "I use cold water to wash my hands" which is relevant for hot water consumption.

Figure 4.3.27 shows that only the second item seems to be relevant for the hot water consumption. Tenants who usually use cold water for hand-washing consumed less hot water than tenants who do not strongly agree. Taking a shower instead of a bath seems to be not as important for hot water consumption in the reporting period. However, it has to be considered again that the analyses base on a small sample size only. In addition to that, the higher cold water consumption of tenants who rather take a shower may also result from interfering influences such as using cold water (to wash hands) instead of warm water.

Figure 4.3.27: Water consumption (reporting period) of respondents with and without ecological behaviour reported in final survey

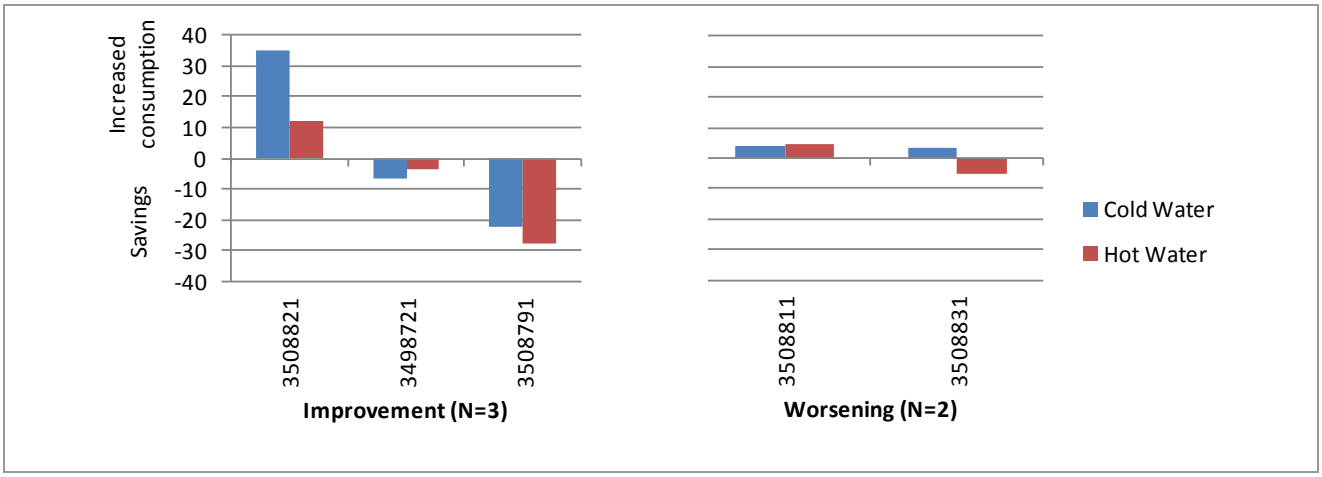


As figure 4.3.28 shows, the change of behaviour related to the item "I rather take a shower instead of a bath" mostly leads to the expected results. For two of the three tenants with an improved behaviour savings of cold and hot water are visible. However, the third tenant shows largely increased cold water consumption and a smaller increase of hot water consumption. This can be explained by the rather low baseline consumption of cold water (14 m^3 per capita) and hot water (11 m^3 per capita).[43] In addition to that, this tenant shows a rather low improvement from "rather agree" to "strongly agree". These two reasons describe that the potential resp. the stimulation for achieving further savings was rather low. Related to both tenants with worsened behaviour nearly no influences on the achievements of savings are visible.

In summary, the results indicate that an improved behaviour can lead to higher savings.

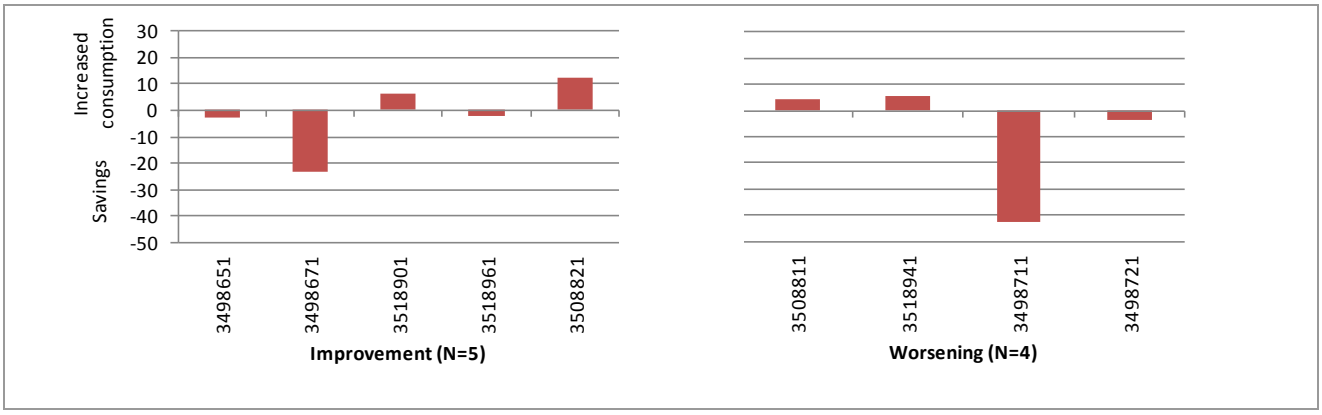
[43] The average consumptions are: cold water: 20 m^3per capita; hot water 13 m^3 per capita

Figure 4.3.28: Percentage change in water consumption for tenants with worsened and improved ecological behaviour for using a shower instead of a bath



With respect to the relation between using cold water for hand-washing and hot water consumption, the influence of a behaviour change is less obvious. However, three out of five tenants with improved behaviour achieved some savings. The consumption increase of two tenants with improved behaviour might be partly explained by the already low consumption during the baseline period (applicable for one tenant) and the within the project duration slightly increased, but in fact rather low agreement with that item (“strongly disagree” in baseline survey; “neither agree nor disagree” in final survey). Among the tenants with worsened behaviour a generally low influence on the achievement of savings can be noticed with exception of one tenant who shows noticeable savings.

Figure 4.3.29: Percentage change in hot water consumption for tenants with worsened and improved ecological behaviour for using cold water to wash hands

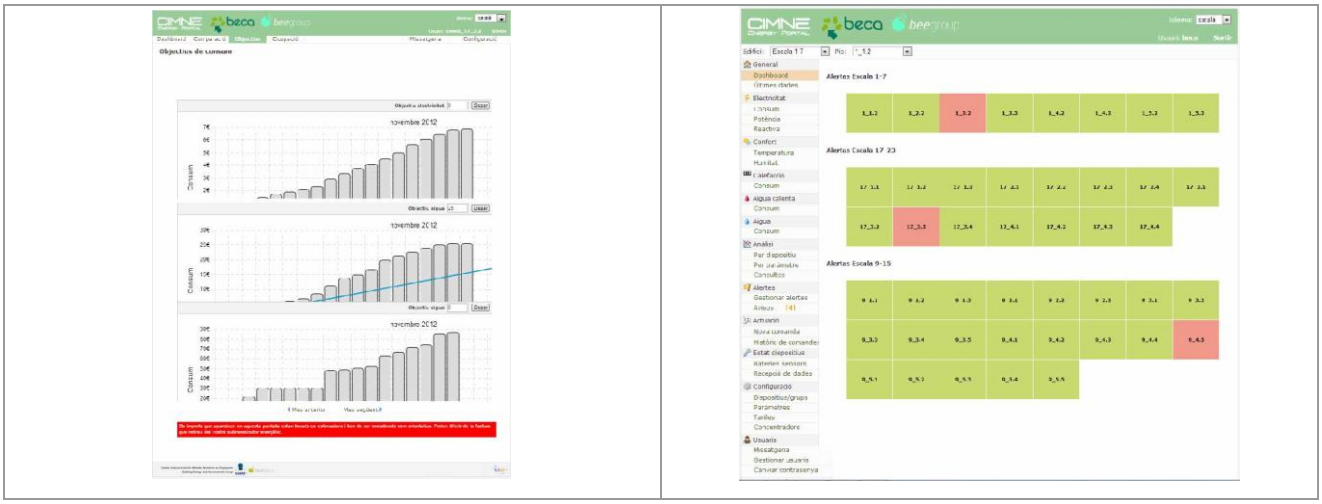


4.4 Manresa

4.4.1 Background information

Manresa implemented a RUAS as well as a RMS. The RUAS includes heat energy[44], cold water as well as electricity and was available in two setups: In the *basic setup* tenants receive feedback on their current energy and resource consumption in combination with information of previous consumption periods, comparisons with neighbour households and average consumption figures of all dwellings in the building. In addition to that tenants were provided with personalised saving tips according to their specific consumption profile by taking into account their self-defined occupancy profiles. Tenants furthermore receive monthly summarising consumption reports via postal letter. In cases of very high consumption figures or abnormal inside temperatures tenants get automated information with corresponding alerts within the web service and a monthly postal letter. The *detailed setup,* which was available for a small sub-group of tenants only, provides additional data as room temperature, humidity, thermostat set-points and electric sub-metering. These tenants were also provided with in-home displays.

Figure 4.4.1: Screen shots of RUAS tenant portal (left) and RMS professional portal (right)



The RMS mainly serves as a monitoring portal for the Manresa staff in order to assure an error-free operation of the heating system incl. solar-supported hot water generation and to receive maintenance warnings.

Both services started operation in October 2012 after a period of baseline measurements which are available for all relevant resources. That in general allows for following the planned evaluation design including pre-post comparisons in combination with a control group approach. However, baseline data of the control group were not available until March 2012 due to delays in the construction phase of the newly built houses. That's why the consumption data analysis had to be different for the several resources:

- Cold water and electricity:
  In order to carry out pre-post comparisons related to both experimental and control group by using comparable time periods, for the purpose of evaluation the reporting period was defined identically to the available baseline measurements of the control group. That's why both analysed comparison periods cover in each case eight months: baseline period:

[44] Incl. solar-supported hot water heating; The originally planned feedback on hot water could not be realised due to technical problems. Although the architecture differentiates between hot water and heating, there is only one single heating meter and there were many months with data errors. It was fixed by the latest months of the project, but it was too late for using these data for comparisons.

March 2012- October 2012; reporting period: March 2013 to October 2013. s
Related to electricity the Manresa project furthermore aimed at a peak demand reduction which is described separately in a specific chapter below.

- Heat energy:
  Related to heating a different approach had to be used which could not include longitudinal pre-post comparisons of the control group. The baseline measurements of the control group cover nearly solely months outside of the heating period which is not as problematic for cold water or electricity, but which is not sufficient for an impact analysis related to heating. That's why in the case of heat energy
  - First, a pre-post comparison was carried out without taking into account the control group. That means, both available comparison periods of the experimental group cover 12 month in each case: baseline period: November 2011 – October 2012; reporting period: November 2012 – October 2013.
  - Secondly, a cross-sectional comparison of the experimental group and the control group was realised using data of the reporting heating period 2012/2013 (November 2012 – April 2013).

In total, 130 dwellings in five buildings were part of the BECA project, but eight dwellings stayed unoccupied within the project duration. Thereof 44 dwellings (in fact 52 including the vacancies) belong to the experimental group with the above mentioned two differently detailed setups[45] (see following table). The control group consists of 78 households in two buildings.

Table 4.4.1: Basic population of dwellings in the experimental and control group in Manresa

Group Status	Montserrat 1-23 (3 buildings)	Montserrat 33-39 (1 building)	Quatre Cantons (1 building)	Total
Exp. group RMS and RUAS (basic setup)	x			38
Exp. group RMS and RUAS (detailed setup)	x			6
Control group		x	x	78
Dwellings with measurements	44*	12	66	122*

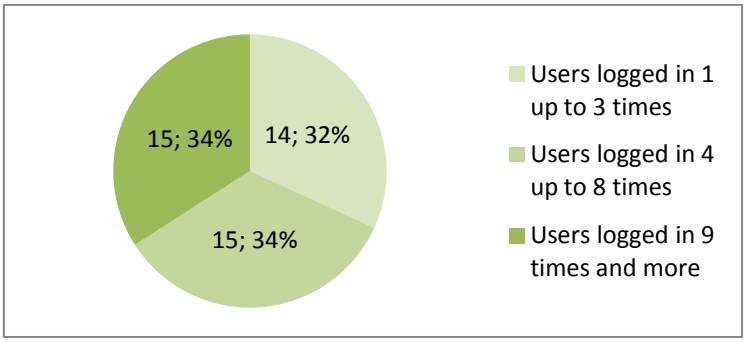
* These figures do not include 8 dwellings unoccupied within the project duration.

Tenant recruitment was realised by a series of reminders starting prior the release of the service and continued during service operation. The idea was to arouse attention and to keep the project idea constantly in mind of the tenants. Therefore several varying posters were put in the staircases, training sessions and face-to-face meetings with tenants took place and monthly (paper) reports were sent to the tenants. All activities based on a CI marketing strategy using a kind of super-hero of energy reduction – called BECO – who serves as an attention catcher especially addressing the youngest. Furthermore tenants could make use of the internet point in the office of FORUM (for further details see D.5.2).

The efforts of Manresa's tenant recruitment were very successful because all experimental tenants became users of the RUAS. The tenants logged in 8.5 times on average in the 12-month observation period. The use frequency had a distribution from one up to 38 times.

[45] That evaluation concept in general allows for further comparisons of both RUAS setups of the experimental group. However, the small number of dwellings in the detailed setup restricts that approach.

Figure 4.4.2: Overview of the portal use frequency of the RUAS users



4.4.2 Results of consumption analysis

In Manresa the consumption analysis was related to heating, cold water and electricity. All data were available dwelling-wise on a monthly basis.

Table 4.4.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise
Electricity	kWh	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. Due to a change of tenancy resp. later move-in dates (which means that baseline data were not available) during the project, a total of 42 dwellings (34%) had to be excluded from the analysis. That was applicable for all three considered energy types/ resources. In addition to that further approximately 10% of the dwellings dropped out because of missing values caused by failures of the metering equipment. As a consequence, more than 50% of the dwellings remained in the analysis sample (see following table).

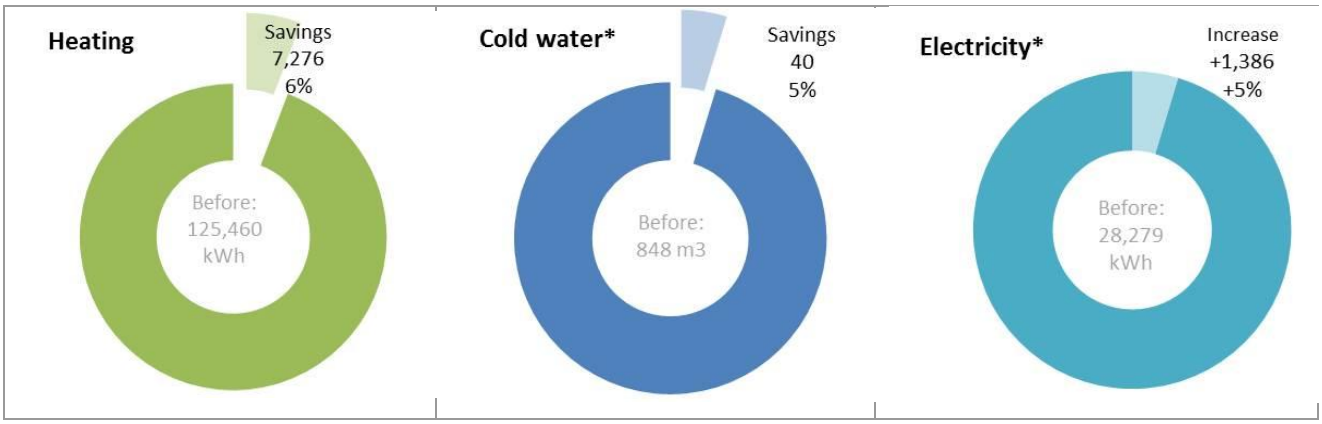
Table 4.4.3: Overview of the number of buildings and dwellings involved in the Manresa pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Manresa	5	122 (+8 unoccupied)	Heating: 66 (exp. 23+contr. 43) Cold water: 68 (27+41) Electricity: 69 (28+41)	Change of tenancy (applicable for all resources): 42 (34%); Exclusion due to missing data: Heating: 14 (11%) Cold water: 12 (10%) Electricity: 11 (9%)

Global results

The calculation of the global savings led to the results shown in the following figure. The tenants of the experimental group saved in total nearly 7.3 thousand kWh heat energy (n=23) and 40m^3 cold water (n=27, related to an 8-month observation period). The electricity consumption of the experimental group increased by nearly 1.4 thousands kWh (n=28).

Figure 4.4.3: Overview of global results of the experimental group in Manresa



* Shortened comparison periods of eight month in each case (see explanation above)

Compared to the target setting of 20% savings in total, it is obvious that – related to electricity – this ambitious goal failed. But the findings described below will show that the experimental group had already comparably low electricity consumption. The average monthly electricity consumption per dwelling in the Manresa pilot is 132 kWh, the mean value in Spain is 208 kWh (source: IDEA). As a consequence, the possibilities of the Manresa tenants to save even more electricity are very limited. Furthermore, it has to be recognised that a big subgroup of experimental tenants (39%) achieved already savings of 15% on average. Apart of that, only three dwellings of the sample are responsible for this consumption increase. This means that related to 90% of the dwellings electricity savings of 1% were achieved. Observing in more detail these three dwellings it becomes clearly that one of them had a more or less two-month absence in the baseline period which increases the value of electricity consumption in the reporting period. The achievement of electricity savings solely by behavioural changes is unequally more difficult than, for example, in the case of heating with the lowering of the room temperatures or the optimisation of the ventilation behaviour. In addition to that, the impact in absolute saving terms is often lower. Significantly higher electricity savings normally could be achieved by replacing old and inefficient electrical appliances by new and efficient ones. That strongly depends on the available income which is assumed to be low in the Manresa pilot site. However, the described already partly success related to a sub-group and the detection of the three dwellings responsible for the increases implies the expectation of further electricity savings in future.

However, the achieved savings of 6% heating and 5% cold water can be attested as a success, they show very positive trends.

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

Table 4.4.4: Overview of global CO_2- and cost savings of the experimental group in Manresa

Energy /resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy (gas)	0.208 kg CO_2/kWh	1.513	0.053 €/kWh	386
Electricity	0.300 kg CO_2/kWh	increase	0.13 €/kWh	increase
Cold water	n/a	n/a	2.95 €/m^3	118
Total		**1,513**		**504**

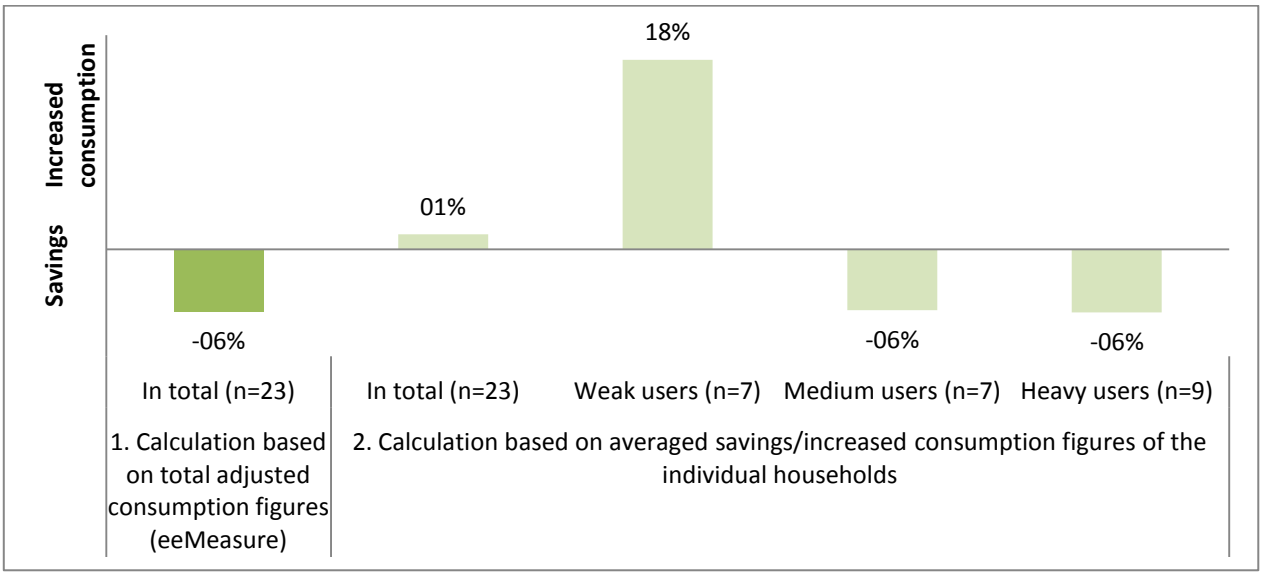
Heating

As introduced above, the heating analysis includes a pre-post comparison of the experimental group and a cross-sectional comparison of the experimental and the control group related to the heating period 2012/2013.

Pre-post comparison (experimental group)

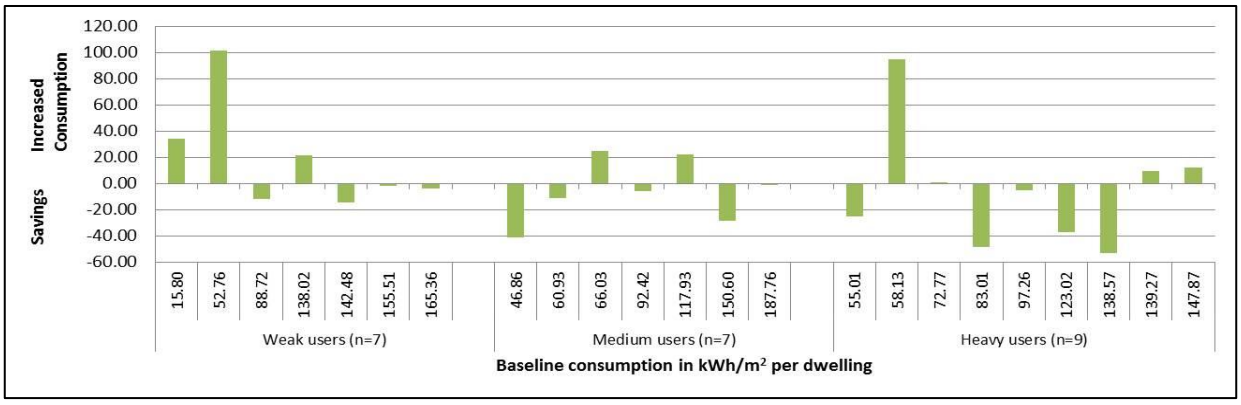
The following figure shows the positive impact[46] of a frequent portal use: Those tenants who logged in at least quarterly achieved savings of 6% (medium and heavy users, for definition see figure 4.4.2 above), whereas the weak users with less logins had an increase of nearly 18%. Nevertheless, the analysis has to be handled with caution due to the very small sample sizes.

Figure 4.4.4: Percentage change in heat energy consumption related to users in total and differentiated by portal use frequency



The divergence between both savings calculation models is again due to the different weights single households carry in one or another direction. In the present case two households with very low – but realistic – absolute baseline consumption had a comparably large increase in relative figures. That led to the small percentage increase when using calculation model 2 compared to the 6% savings calculated with model 1 which is used by eeMeasure.

Figure 4.4.5: Savings resp. increased consumption per household (in %) related to the baseline consumption per dwelling (in kWh/m^2) differentiated by portal use frequency



[46] RMS and RUAS are considered together as the services cannot be separated.

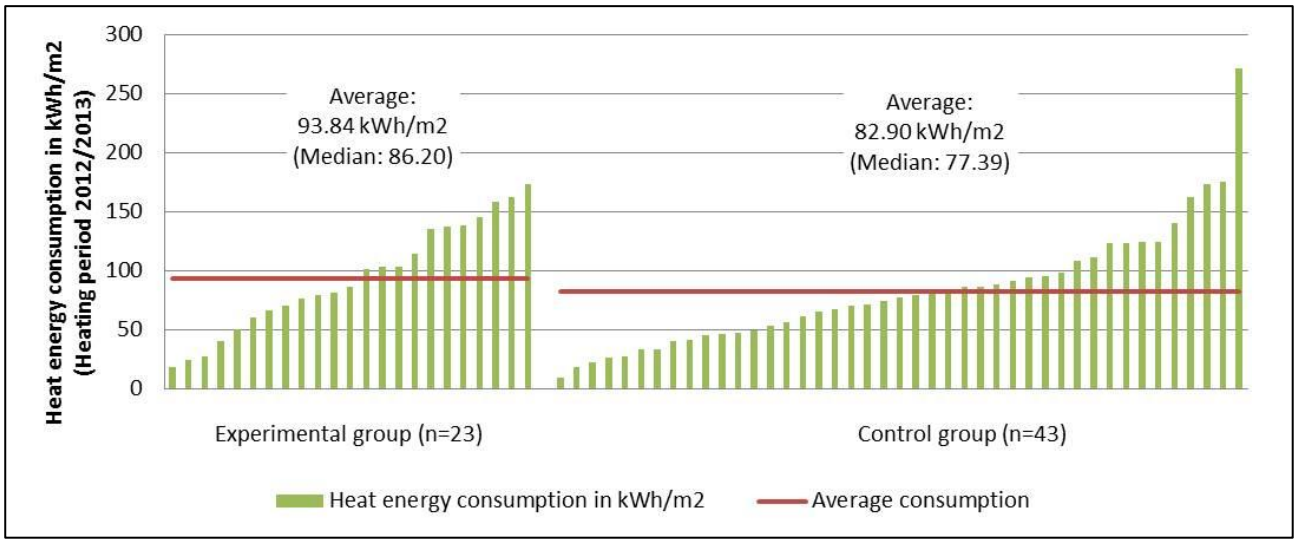
In total 14 households (61%) achieved heat energy savings of 21% on average, nine households (39%) had a consumption increase of 36% on average.

The three households remaining in the analysis sample after data cleansing and using the detailed RUAS setup belong to the group of heavy users. They had savings of 4.4% on average.

Cross-sectional comparison of experimental and control group

The following figure shows that the experimental group had about 13% larger heat energy consumption on average in the reporting heating period than the control group which was similarly reported by the pilot site manager also for previous years. This finding can be clarified with the energetic quality of the control buildings which is better compared to the experimental building. According to the report of the pilot site manager the control buildings are constructed more compactly, so that their dwellings have smaller facing surface areas than the dwellings of the experimental building which normally results in better heating performance.

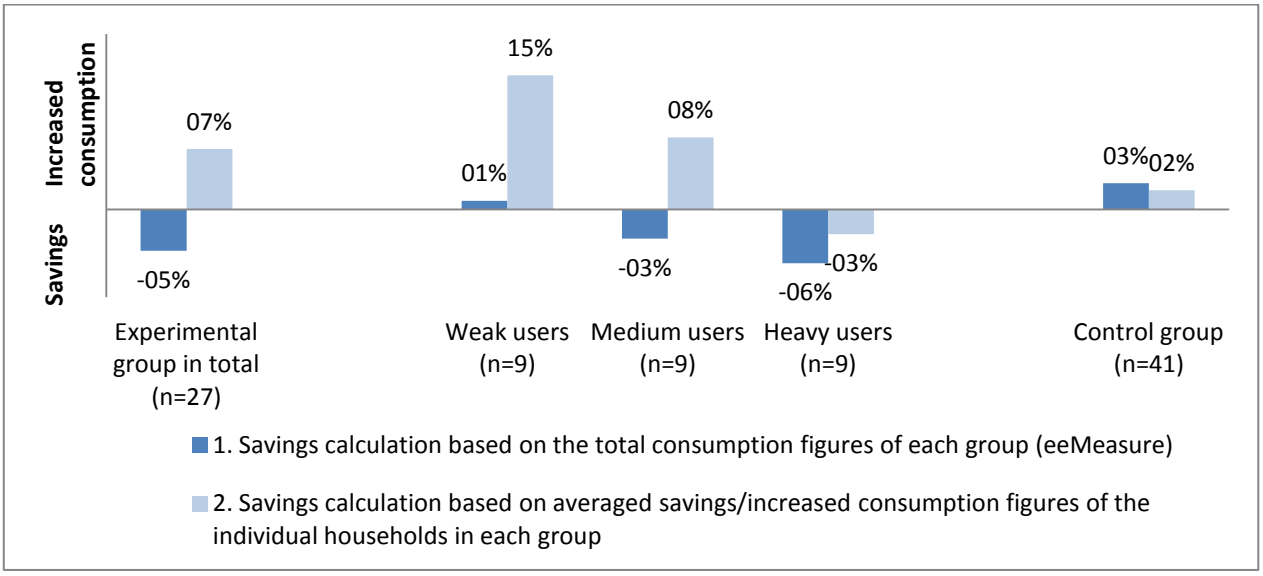
Figure 4.4.6: Cross-sectional comparison of heat energy consumption in kWh/m^2 of experimental and control group in the reporting period (heating period 2012/2013)



Cold water

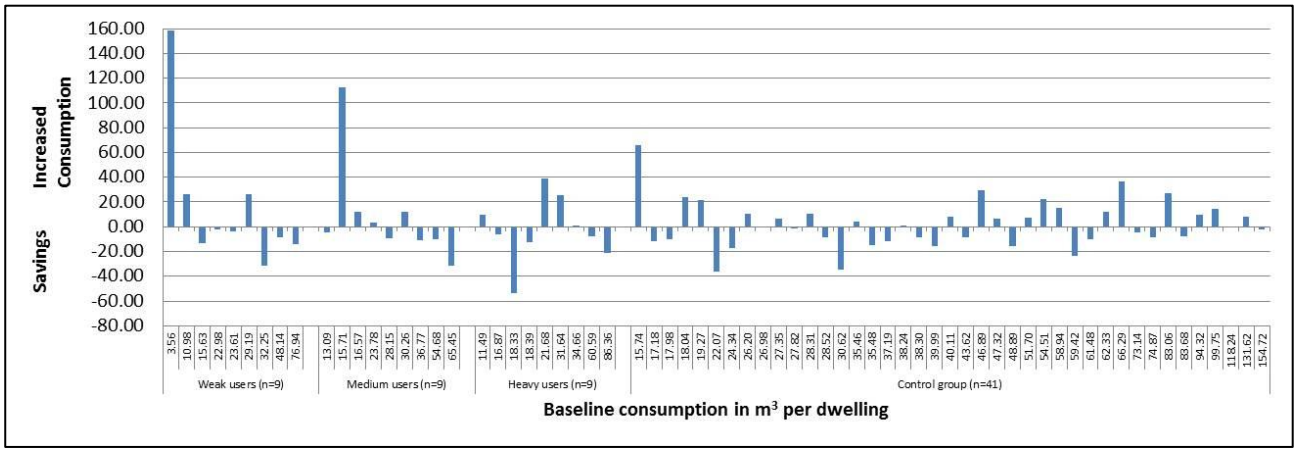
Again the small sample sizes have to be taken into account when interpreting the results. The following figure shows once again that both used calculation approaches can result in different percentages of savings resp. increased consumption which has a mathematical explanation. In the present case that is especially relevant for the experimental group: Two households with low, but realistic, absolute baseline consumption had a comparably large increase in relative figures. That led to the percentage increase of 7% when using calculation model 2 compared to the 5% savings calculated with model 1. Clearer are the results for the control group with consumption increase in any case.

Figure 4.4.7: Percentage change in cold water consumption related to experimental and control group



As already applicable for heating, the portal use frequency had a positive impact on the results. Especially heavy users, but also medium users of the RUAS had a better performance than the weak users.

Figure 4.4.8: Savings resp. increased consumption per household (in %) related to the baseline cold water consumption (in m^3 per dwelling)

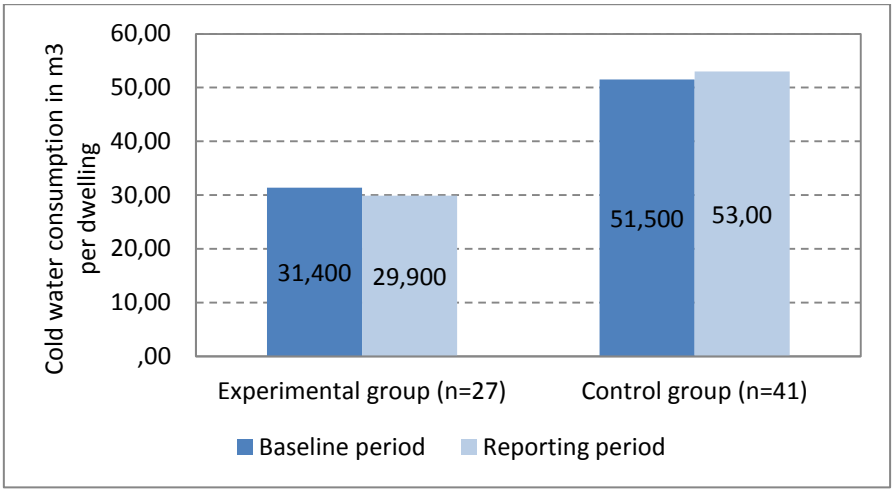


Due to missing information about the household size in the control group, which was not available in Manresa, the following overview shows the average cold water consumption in m^3 per dwelling.[47] That means that the findings are subject to considerable uncertainty. In contrast to heat energy consumption - where the number of persons living in is not as important – or compared to electricity consumption – where surface-adjusted figures can improve the comparability – the number of persons in a household has an important influence on water consumption. Within the combined analysis in section 4.4.4 the average consumption per capita will be examined for a subgroup of tenants based on the survey answers.

[47] The average dwelling sizes in both comparison groups were very similar: experimental group 53.2 m^2, control group 52.4 m^2.

By comparing the dwelling-wise data as makeshift method, the RUAS users had already in the baseline period a lower consumption level and reduced it further by 1.5 m^2 per dwelling on average. The control group had in the same observation period an increase of 1.5 m^2 per dwelling on average.

Figure 4.4.9: Average cold water consumption in m^3 per dwelling related to experimental and control group



In the experimental group relatively more households (59%) achieved savings than in the control group (51%). In addition to that, in these experimental dwellings the savings were a bit higher than in the corresponding dwellings of the control group.

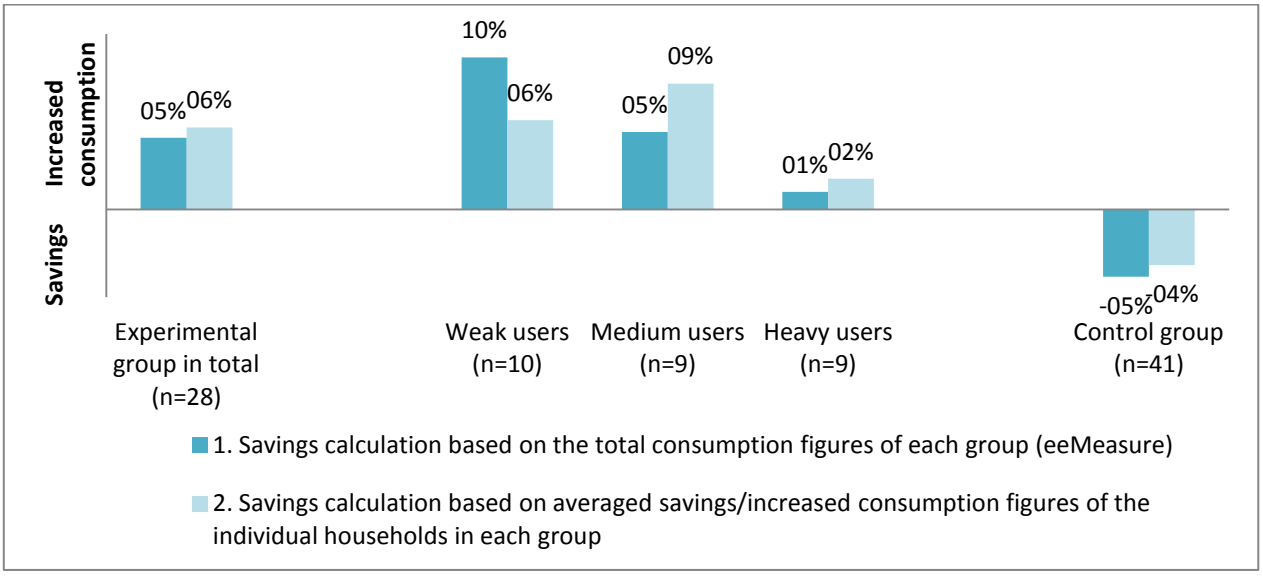
Table 4.4.5: Percentage of dwellings with cold water savings/increased consumption and correspondent average figures related to experimental and control group

	Experimental group	Control group
Absolute number and percentage of dwellings with savings	16 (59%)	21 (51%)
Average savings of dwellings with savings	-15.0	-11.9
Absolute number and percentage of dwellings with increased consumption	11 (41%)	20 (49%)
Average increased consumption of dwellings with increased consumption	+38.7	+17.1

Electricity

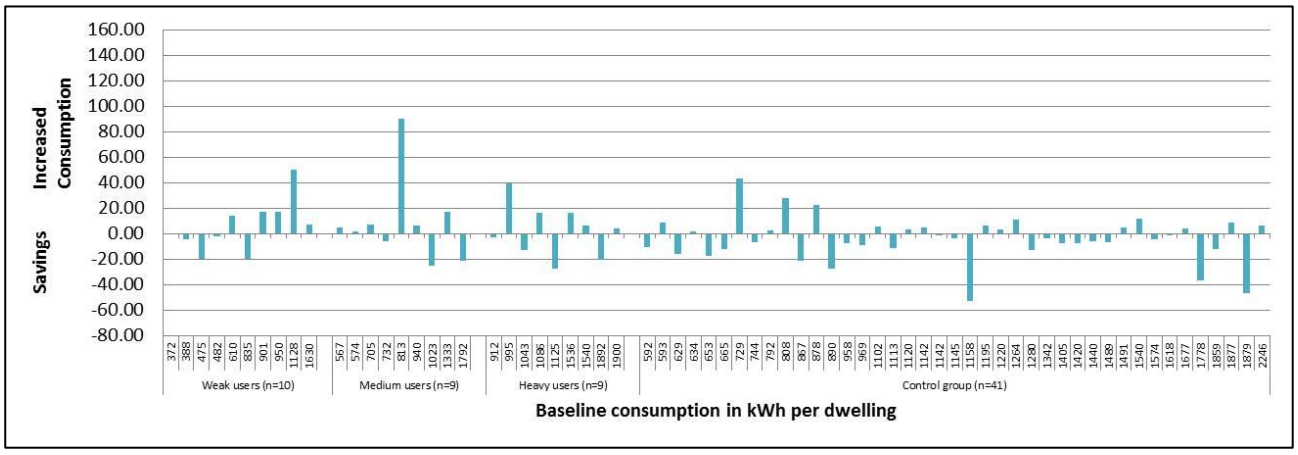
Related to electricity the following figure shows that the control group achieved better results than the experimental group. As to be seen below, that is mainly due to the already low consumption of the experimental group with restricted possibilities to achieve further savings. However, a positive impact of a frequent RUAS use still became obvious because the consumption of the RUAS heavy users stayed nearly constantly, whereas the tenants with a lower use frequency had a more significant increase. It has to be noted again, that the analysis has to be handled with caution due to small sample sizes.

Figure 4.4.10: Percentage change in electricity consumption related to experimental and control group



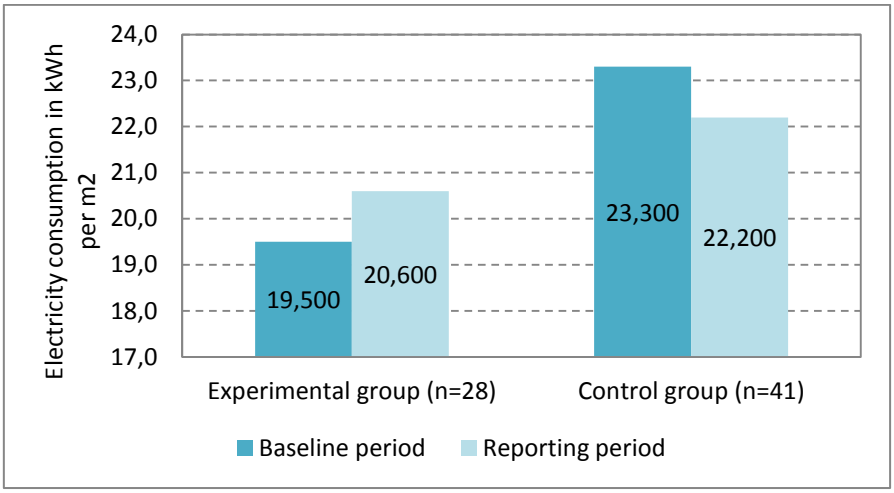
The divergence between both calculation approaches is again due to single extreme values which carry weight differently in the one or the other direction (see following figure). However, in the present case the deviation of the calculation results is quite low.

Figure 4.4.11: Savings resp. increased consumption per household (in %) related to the baseline electricity consumption (in kWh per dwelling)



Due to the absence of information about household sizes of the control group, the following figure shows the average consumption per square meter net dwelling area before and after the implementation of the service related to both comparison groups. As it becomes apparent, the user households/experimental group already in the baseline had and in the reporting period still have lower electricity consumption than the control group. This is an indicator of the limited possibilities to achieve even better consumption levels.

Figure 4.4.12: Average electricity consumption in kWh/m² related to experimental and control group



This result is reflected in the following table which shows that a higher percentage of control group tenants achieved savings. Anyway, also 39% of the experimental group could reduce their already low electricity consumption furthermore.

Table 4.4.6: Percentage of dwellings with electricity savings/increased consumption and correspondent average figures related to experimental and control group

	Experimental group	Control group
Absolute number and percentage of dwellings with savings	11 (39%)	24 (58%)
Average savings of dwellings with savings	-14.6	-13.9
Absolute number and percentage of dwellings with increased consumption	17 (61%)	17 (42%)
Average increased consumption of dwellings with increased consumption	+18.7	+11.0

Electricity – Peak Demand Reduction

The efforts related to peak demand reduction within the BECA project were still on a very basic level. Tenants got general information to avoid using many appliances at the same time, but they neither receive alerts or the like in the case of peaks nor could make use of different electricity tariffs.

The analysis followed the recommended approach of the common deliverable on methodology[48] by using a ten-day average of working days/four-day average of weekends of the baseline as well as of the reporting period. In order to minimise confounding variables both periods furthermore should be mostly identical related to natural light/ sunshine duration. The chosen periods were as follows: baseline period: 15 Oct 2012 – 28 Oct 2012; reporting period: 14 Oct 2013 – 27 Oct 2013. In both cases there was a clock change at the last Sunday of the period. The periods covered in each case the same 36 households. The data analysed base on hourly measurements on a 24-hours scale.

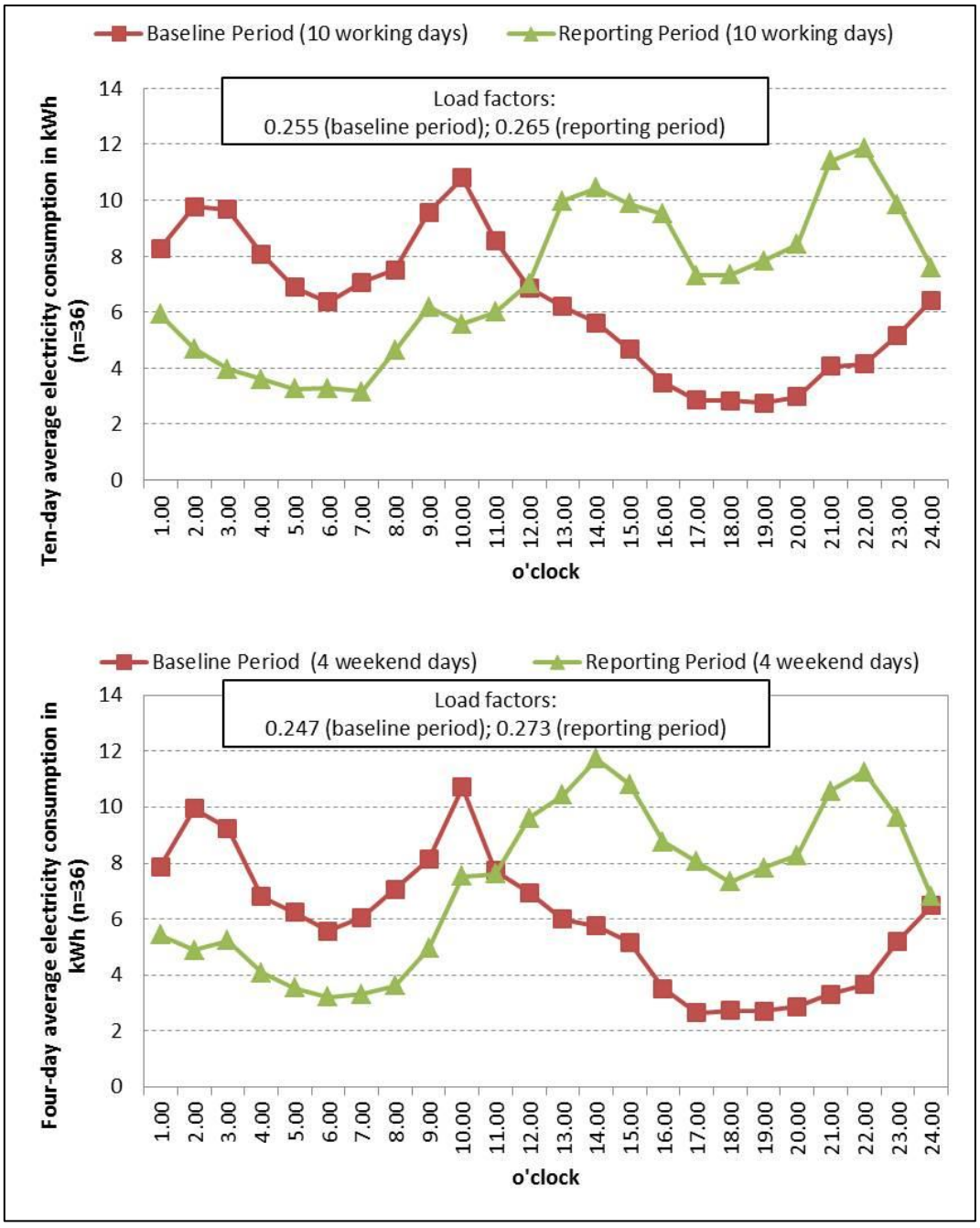
The following figures show separately for working days and weekends that the early morning and forenoon peaks of the baseline period could be shifted in the afternoon and late evening in the

[48] http://beca-project.eu/fileadmin/BECA/documents/beca_residential_methodology.pdf

reporting period. That is applicable for working days as well as weekends. However, that is not a flattening of the curve. The load factor[49] of the reporting period, which is the relation between the minimum consumption divided by the maximum consumption and which describes the peak flattening, is only minimally better than the baseline figure.

Nevertheless, both figures show a first positive impact to such an extent, that the tenants were willing to change their points in time when using electrical appliances. Providing them with more specific information could be helpful in order to achieve an actual flattening of the curve. Therefore further supporting instruments as described below (e.g. alerts, improvements of the tariff structure) seem to be necessary.

Figure 4.4.13: Electricity load curves of working days and weekends incl. load factors related to both comparison periods



[49] The closer the load factor is to the value 1, the less peaks of the demand curve are obvious.

4.4.3 Results of survey analysis

Results of mid-term survey

The mid-term survey was realised with seven tenants of the experimental group (both setups) and four staff members.

Six of the seven tenants learned from the information provided by the portal. The information is assessed as useful in order to get a general overview of the energy consumption and to learn about which appliance consumes how much energy. All respondents were of the opinion that the portal enables tenants to save energy. Five tenants already tried to implement the energy saving tips. For four interviewed tenants the portal was not a topic of conversation. Two tenants mentioned that the shown images were initially somewhat difficult while the other five tenants had no understanding problems. One tenant reported on occasional problems when establishing a connection, but the interviewer detected and removed that configuration problem. In another case that problem occurs only once. The tenants have few suggestions for improvements only – for example, the provision of reference values[50] in order to evaluate the own consumption as high, medium or low, more saving tips, bigger lettering and pictures and improvements of the comprehensibility.

The use frequency of the portal would be higher in cases of

- an available Smartphone solution,
- an available permanent internet access at home,
- more available time or
- extremely high annual energy bills

All interviewed tenants are interested in the monthly reports. Related to that, one tenant has difficulties to understand it, one tenant reads it directly after receiving, one tenant reports that he together with neighbours discussed and compared it.

All interviewed tenants think that posters in the common spaces of the building serve as good reminders. Also all of them value the energy tips of BECO as interesting and useful. One tenant used the internet point in the Forum's office when he had problems with his personal computer.

All four interviewed employees learned from the information the portal provided, especially about the tenant's consumption habits. They believe that tenants are enabled to save energy with the help of the portal. The portal shows which kind of energy has been consumed most and at which time of the day the consumption is high. Furthermore, the portal helps to detect habits and behaviour patterns which cause high energy consumption. All employees discussed the portal with their family and use the provided energy saving tips at home by themselves. For three of them the graphics and images of the tenant portal are easy to understand. One person had some understanding and acceptance problems at the very beginning which have been solved in the course of time. Portal usage problems seldom occurred and normally can be solved by a repeated login.

The interviewed employees suggested these improvements:

- Availability of more supporting information,
- Improvements of the navigation,
- Revisions of historical comparisons (e.g. same period of the previous)
- Possibilities of selecting cut-outs (e.g. of a consumption period) taken from a calendar
- Availability of an info sheet with all relevant information of the dwelling on one screen

In addition to that, an alarm function could increase the portal use frequency. The monthly report is assessed as very helpful and useful – for example, after receiving the report the tenants' log-ins

[50] It has to be mentioned that reference values have already been provided (comparative feedback: comparison with other households; historical feedback: comparison with previous periods).

increases. An employee proposes to improve the design. Concordantly the posters are a very good idea in order to remind the portal. The same applies to the energy saving tips of BECO which are interesting and useful.

Data basis and profile of respondents at baseline and final survey

Table 4.4.7 shows the number of respondents per survey stage. Pre-post comparisons could be carried out with survey data of 41 tenants of the control group and 25 tenants of the experimental group who participated in both survey stages. A further differentiation related to the two available RUAS setups is not appropriate due to the very small sample sizes in the detailed setup (n=4).

The response rates in both evaluation groups are very satisfactory: 72% of the tenants of the control group participated in the baseline survey and 75% in the final survey. In the experimental group the response rate is even higher with 81% resp. 80%. This is the result of the high motivation of tenants for participation and the good organisation of the survey. Tenants have been informed with personal letters five days prior the planned survey start. Tenants who would be absent at the scheduled visit date were asked to give a phone call to the office. Besides, all tenants were contacted on at least two different days and different hours. In case of unattainability they received a note asking them again for calling the office and arranging another meeting. Furthermore, not available tenants were contacted once again by phone in order to make an appointment. Lastly tenants could use a paper questionnaire instead of a face to face interview. It has to be noticed that such a sophisticated survey work was realisable because Manresa is a rather small pilot site in the BECA project.

Table 4.4.7: Number of respondents per survey stage

Participation at survey stage	Evaluation Group			Total
	Control Group	Experimental Group (basic RUAS setup)	Experimental Group (detailed RUAS setup)	
Only baseline survey	11	8	1	20
Only final survey	16	9	1	26
baseline and final survey	41	21	4	66
Total	68	38	6	112

The profile of the respondents who participated at least in the final survey and of those with participation in both stages is shown in the following table.

Except the equal average household size of two persons in both groups (median value), it becomes obvious that there are noticeable differences between the control and the experimental group that may have an influence on the impact of the services. Some of those differences are considered in the combined analysis in section 4.4.4.

If not reported otherwise, the differences apply to tenants who have at least participated in the final survey and to tenants who have participated in both panel stages. In the experimental groups male respondents are sligthly over-represented (54% and 56%). Additionally, the majority of respondents are born in Spain in both groups, but the proportions are much higher in the experimental group. This means that different cultural backgrounds could influence the behaviour and savings. The respondents of the experimental group are slightly younger (median: 49 years each) than respondents in the control group (median: 54 respectively 51 years). At the same time the level of education is slightly higher in the experimental group with fewer tenants without school living qualification, but more tenants with primary/secondary school leaving qualification. However, the differences in age and education level are not as big, so that no major influences on the energy

consumption are expected. Furthermore, the experimental group shows longer absences of all household members from their homes at a normal weekday than in the control group. This means that the experimental group is more likely consuming less energy due to this and it is more likely that there are smaller energy saving potentials and restrictions on the suggested actions.

Table 4.4.8: Profile of respondents in relation of survey participation

Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
Sex	Male	23 (40%)	19 (54%)	13 (32%)	14 (56%)
	Female	34 (60%)	16 (46%)	28 (68%)	11 (44%)
Country of birth	Spain	35 (61%)	27 (77%)	24 (59%)	18 (72%)
	Other	22 (39%)	8 (23%)	17 (42%)	7 (28%)
Age	Mean	56	49	57	56
	Median	54	49	51	49
Level of education	No school leaving qualification	16 (31%)	5 (14%)	11 (30%)	3 (12%)
	Primary/secondary school leaving qualification	17 (33%)	15 (43%)	11 (30%)	11 (44%)
	Secondary school leaving qualification	11 (21%)	10 (29%)	9 (24%)	7 (28%)
	University entrance qualification	5 (10%)	3 (9%)	4 (11%)	3 (12%)
	University/university of applied science degree	3 (6%)	2 (6%)	2 (5%)	1 (4%)
Size of household	Median (persons)	2	2	2	2
Absence of all household members at normal week day	0-2 hours	25 (45%)	10 (29%)	17 (43%)	7 (28%)
	3-5 hours	15 (27%)	11 (31%)	14 (35%)	9 (36%)
	6-8 hours	8 (14%)	7 (20%)	4 (10%)	4 (16%)
	More than 8 hours	8 (14%)	7 (20%)	5 (13%)	5 (20%)
Rent or service Charges paid by municipality	No	43 (77%)	31 (89%)	31 (76%)	22 (88%)
	Rent	13 (23%)	4 (11%)	10 (24%)	3 (12%)

The majority of tenants in both groups receive no financial support from their municipality, state or other institutions, but the proportion in the experimental group is even higher (89% resp. 88%)

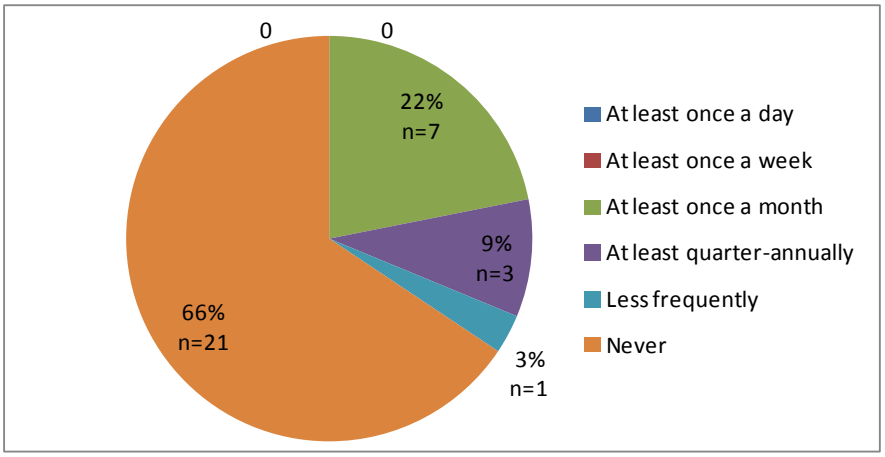
compared to the control group (77% vs. 76%). This means that the experimental group may have a higher motivation for achieving energy savings in order to save money than the control group.

RUAS use and motivation of tenants

91% of the tenants in the experimental group who participated at least in the final survey stated that they have already heard from the tenant portal (32 out of 35 tenants). That does not apply to the remaining three tenants who probably did not remember the portal in the moment the question was asked to them. Maybe they didn't read the information letters, didn't notice the posters or just forgot it in the course of time.

Among the remaining 32 respondents there are ten tenants who log in the tenant portal at least quarter-annually (31%). Most of these active users log in once a month. 22 respondents are no active portal users because they reported on non-usage or less frequently than quarter-annually log-ins. Therefore they have not been asked about the satisfaction with the portal. However, the measured log-in data (see above) showed that all households became active users. That underlines the conclusion (as already indicated in section 2.2.2) that not always the respondent himself, but another member of the household uses the portal.

Figure 4.4.14: Frequency of portal use
(n=32; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

Prior the start of the RUAS services, the motivation to save energy consists within the experimental group (all tenants participated in both surveys) predominantly in saving money and protecting the environment equally (80% or 20 out of 25 tenants). The motives of the remaining tenants are saving money more than protecting the environment (12% or 3 tenants) or solely saving money (8% or 2 tenants).

Control group tenants more often have monetary motivations (29% or 12 out of 41 tenants agreed with the category "solely to save money"; 27% or 11 tenants agreed with "save money and protect environment equally"). Both aspects equally are motives of 39% of the control group tenants (16 tenants). For two tenants the protection of the environment is more important than the money aspect.

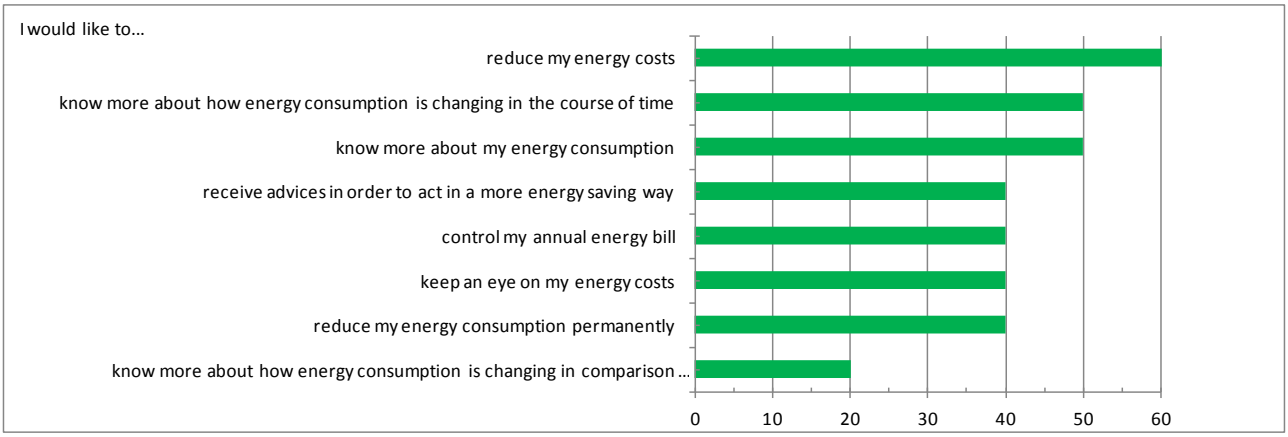
In summary, the tenants of the experimental group seem to have a slightly higher intrinsic motivation for saving energy due to environmental aspects.

Reasons for using and for not using the tenant portal

The ten active users were asked for the reasons of using the portal. Based on the answer category "strongly agree" the reduction of energy costs can be identified as most important because six out of ten tenants strongly agree with it. In addition to that, the active users would like to know more about their energy consumption and how it is changing in the course of time (in each case five

tenants strongly agreed). Further reasons are less important as not more than four tenants strongly agree with them.

Figure 4.4.15: Reasons for using the tenant portal
(n=10; active users; percentages for "I strongly agree")



Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

The question about the reasons for non-usage of the tenant portal was addressed to all tenants of the experimental group who do not belong to the active users. However, the provided statements were not of relevance. 21 out of 22 tenants responded with "don't know" related to all probable reasons. The remaining person chose the answer category "neither agree nor disagree". These results can also be caused by the low motivation to answer that question due to the low interest in the portal. That's why the results can hardly be interpreted.

Impact on ecological awareness

Figure 4.4.16 shows the change of ecological awareness before and after the RUAS use related to both experimental groups together.

Especially with regard to the more generally phrased statements, but also related to the personal interest in energy saving issues at home there is a high level of ecological awareness obvious – already prior the use of the RUAS. Indeed, this high level cannot be completely kept over time, but it remains at a high level. This is true for the statements

- "Protecting the environment is a very important issue",
- "The decrease of carbon dioxide is important for the environment";
- "I am interested in my energy consumption at home" and
- "I am interested in possibilities of saving energy at home".

The proportions of tenants who strongly or rather agree with these statements are at least 84% which corresponds to a high ecological awareness. A positive trend can be found regarding the subjective energy saving norm ("I should save more energy at home") with an increased compliance from 36% to 48% in the pre-post comparison.

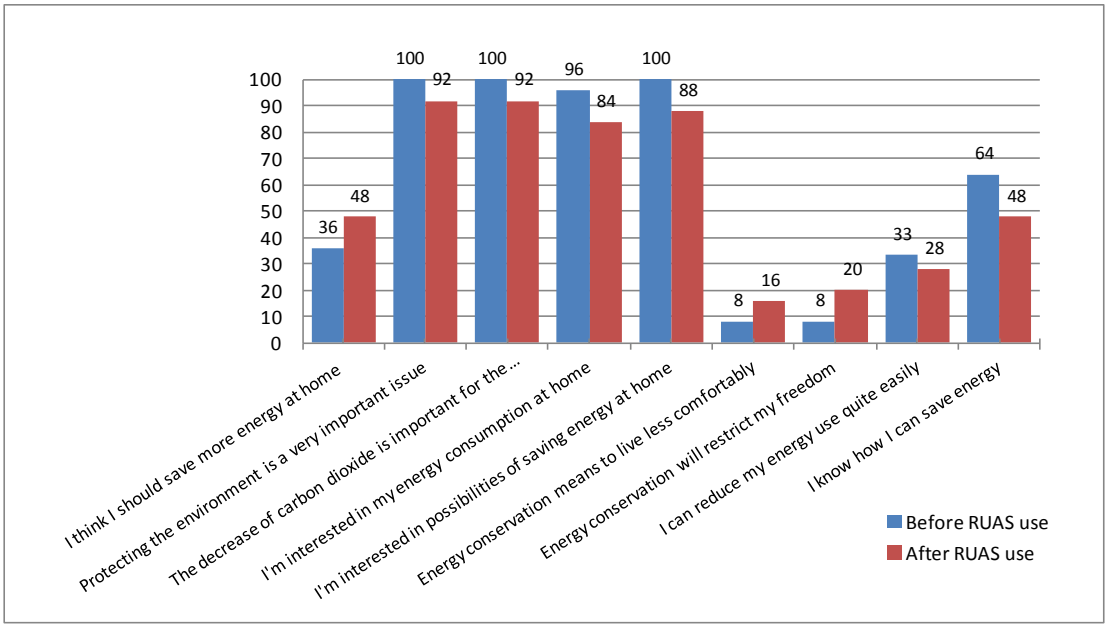
A little bit striking is the slightly negative trend of the statement "I know how I can save energy". Maybe the tenants did not enough notice the energy saving tips provided in the tenant portal and by the posters. Another – more self-evident – explanation might be that some tenants got the impression that they comply with saving tips and behave carefully, but their energy bills do not decrease accordingly due to the increased energy prices.[51] As energy bills stay in mind and

[51] According to the pilot site manager the prices increased constantly over the past years.

probably give a feeling of not having achieved energy savings (even if there is less consumption), that could motivate tenants to believe that they don't know how to save energy.[52]

An additional positive result is that the respondents rather feel not restricted by energy conservation actions. This opinion is not very much rising in the course of time. At final stage (after the RUAS use) only 16% think that energy conservation means to live less comfortably and 20% think that it will restrict their freedom. Furthermore, at least 28% of the tenants agreed that they can reduce their energy use quite easily.

Figure 4.4.16: Ecological awareness of experimental group tenants before and after RUAS use
(n=24-25 due to missing values); percentages for answer categories "strongly agree and rather agree")

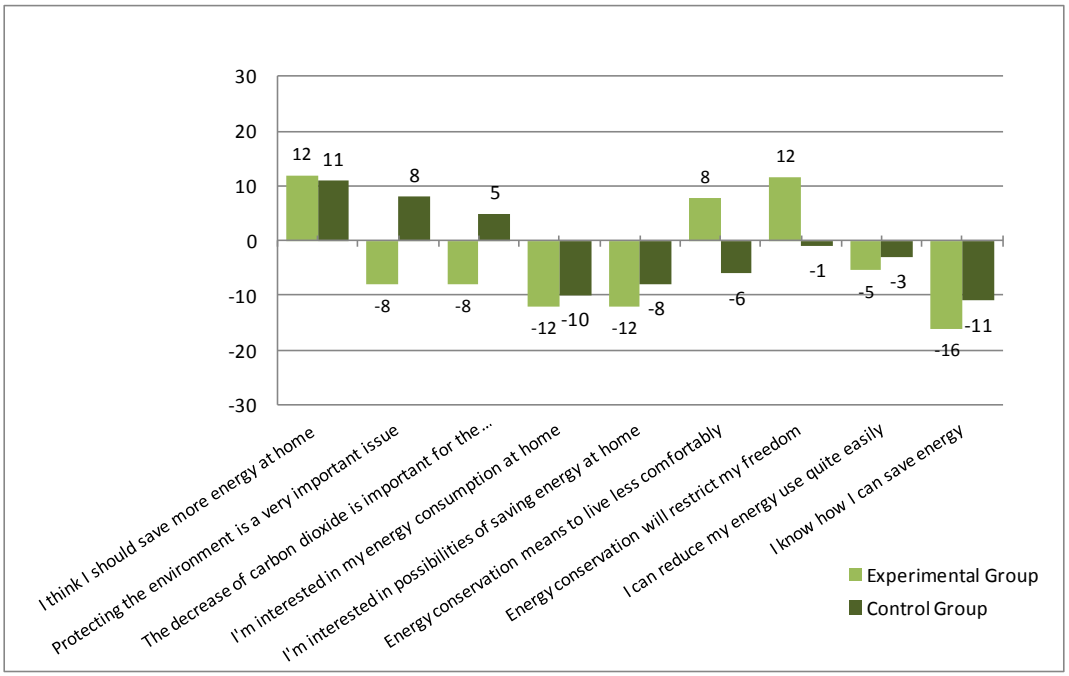


Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

Figure 4.4.17 shows that there are similar trends in the experimental group and the control group. Per se this indicates the absence of net impacts of the RUAS on ecological awareness. But negative trends in the experimental group are very likely resulting from the already high awareness levels before service operation which cannot or only hardly be raised. This is especially true for two statements with positive trends in the control group, but negative trends in the experimental group ("Protecting the environment is a very important issue", "The decrease of carbon dioxide is important for the environment").

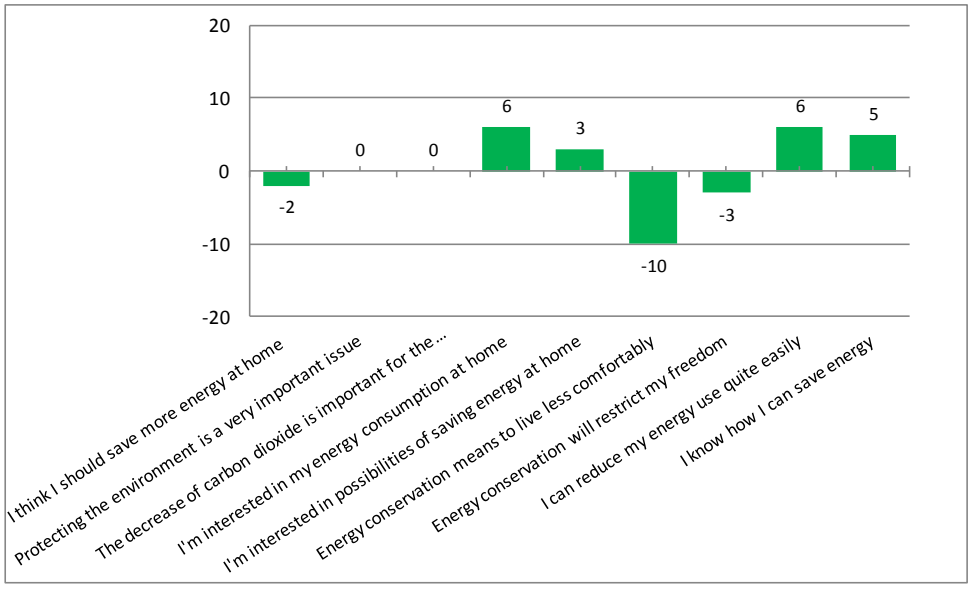
[52] In addition to that, when dealing with staff of social housing companies, tenants usually complain when it comes to money issues (also energy costs) and their own responsibility to change their situation.

Figure 4.4.17: Changes of ecological awareness of experimental group and control group tenants (n=24-25 (exp.) and n=38-41 (contr.) due to missing values[53]; pre-post comparisons; percentage point differences for answer categories "strongly agree and rather agree")



In addition to that, the following figure shows again the differences between experimental group and control group at final stage. It becomes obvious that the experimental group has a slightly higher ecological awareness than the control group.

Figure 4.4.18: Differences between experimental group and control group at final stage (n=24-25 (exp.) and n=38-41 (contr.) due to missings[54]; percentage point differences for answer categories "strongly agree and rather agree")



Taking into account the trends in the course of time and the initial situations at baseline stage, especially the findings regarding four statements can be interpreted as very positive results:

[53] Answer categories „not applicable" and "don't know" were coded as missing.

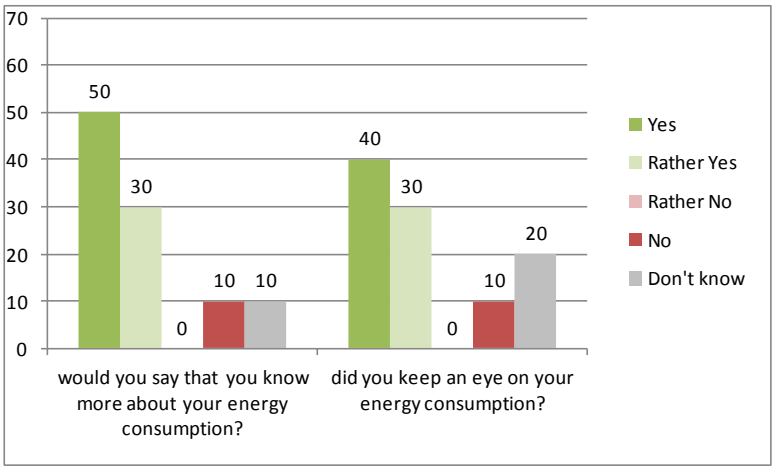
[54] Answer categories „not applicable" and "don't know" were coded as missing.

Compared to the control group the experimental group shows higher awareness in terms of personal interest in possibilities of saving energy at home and in terms of knowledge how to save energy. This is at least partly resulting from the RUAS use. At the same time the experimental group feels less restricted by energy conservation actions. This is true for the statements “Energy conservation means to live less comfortably” and “Energy conservation will restrict my freedom”. This shows that the tenants of experimental group – as a result of the RUAS use – are more likely adapting their behaviour as they feel less restricted than the control group.

The realisation of mean comparisons (e.g. t-tests) is not possible due to the too small sample size of the experimental group.[55]

Among the ten tenants who are using the tenant portal actively, the majority states to know more about their energy consumption and to keep an eye on their consumption due to the tenant portal. The increased knowledge is confirmed by eight out of ten tenants (“yes” or “rather yes”), the higher attention to their energy consumption by seven tenants. Only one tenant denies both aspects, one respectively two tenants are not decided. This shows – related to these aspects – that the tenants themselves attribute a meaningful function to the tenant portal.

Figure 4.4.19: Knowledge and relevance of energy saving issues resulting from RUAS use
(n=26; percentages)



Question: Thinking of the provided tenant portal…
- would you say that you know more about your energy consumption?
- did you keep an eye on your energy consumption?
Answer categories: “Yes”, “Rather yes”, “No”, “Don*t know”.

In summary, it can be concluded that the potential for further increases of the ecological awareness by using the tenant portal is low because especially the tenants of the experimental group showed already high levels at the baseline stage. However, taking this fact and the developments of both groups into account, there can be found positive influences of the RUAS on the personal interest in possibilities of saving energy at home and the knowledge of tenants. The same applies to the perceived restrictions of tenants that are lower in the experimental group. Even if it cannot be excluded from a statistical point of view that also other factors than the tenant portal have an influence, the at least partly impact of the tenant portal is confirmed by the retrospective view of the active users about knowledge and relevance of energy saving issues.

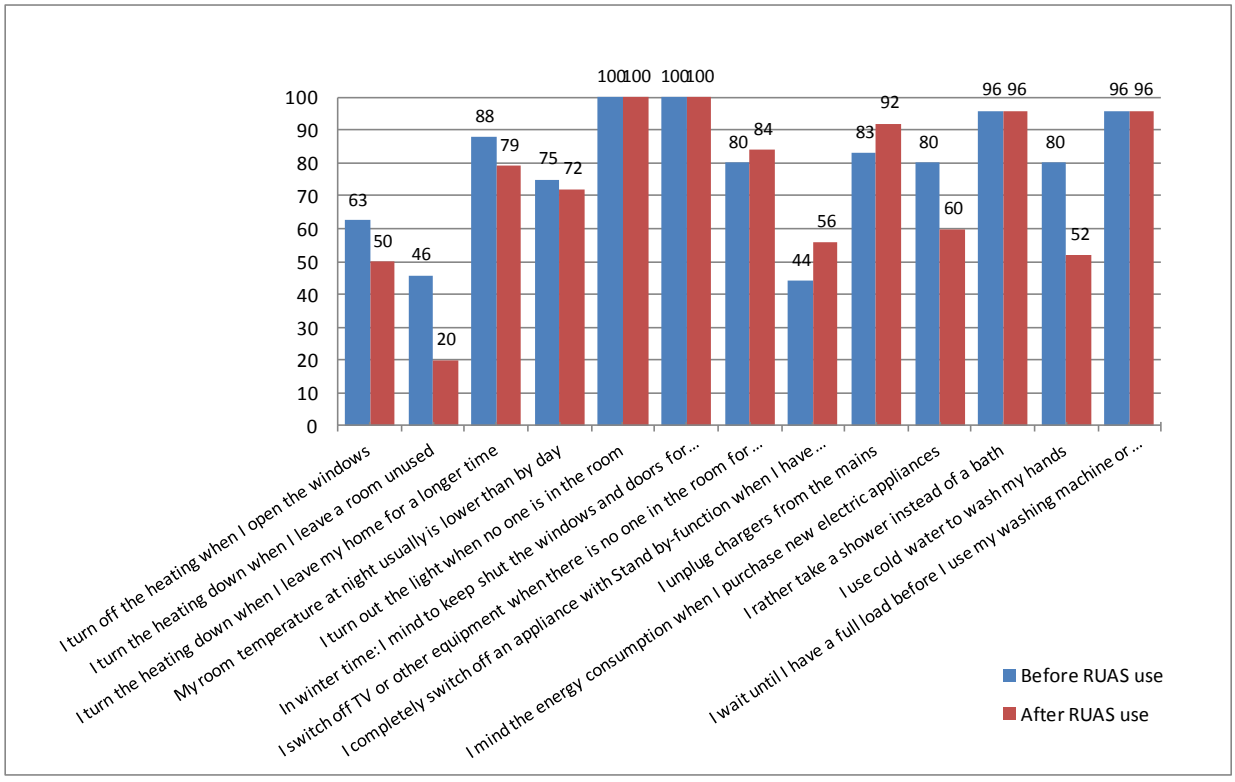
[55] The cut off point is at N=30; in the experimental group there are not more than 25 tenants who answered to the questions at baseline and final survey stage.

Impact on ecological behaviour

The pre-post comparisons of the consumption behaviour in the experimental group show positive developments or constant high values for many statements. Most of them refer to electricity consumption such as turning out the light when no one is in the room; waiting until a full load before using dishwasher or washing machine. Nearly all tenants agreed with these statements already at baseline stage, but on constant level also at final stage. The same applies to shutting windows of common rooms in winter time and taking a shower instead of a bath. As a consequence, a potential for further behaviour optimisation was not given, but the RUAS services may helped to hold the level steady.

Behaviour improvements are related to the items “switching off TV or other equipment when no one is in the room”, “completely switching off appliances with Stand by-function” and “unplugging chargers from the mains”. Here the initial situation shows lower levels of ecological behaviour that rises by up to 12%-points.

Figure 4.4.20: Ecological behaviour of experimental group tenants before and after the use of RUAS
(n=20-25 due to missings[56]; percentages for answer categories “strongly agree and rather agree”)

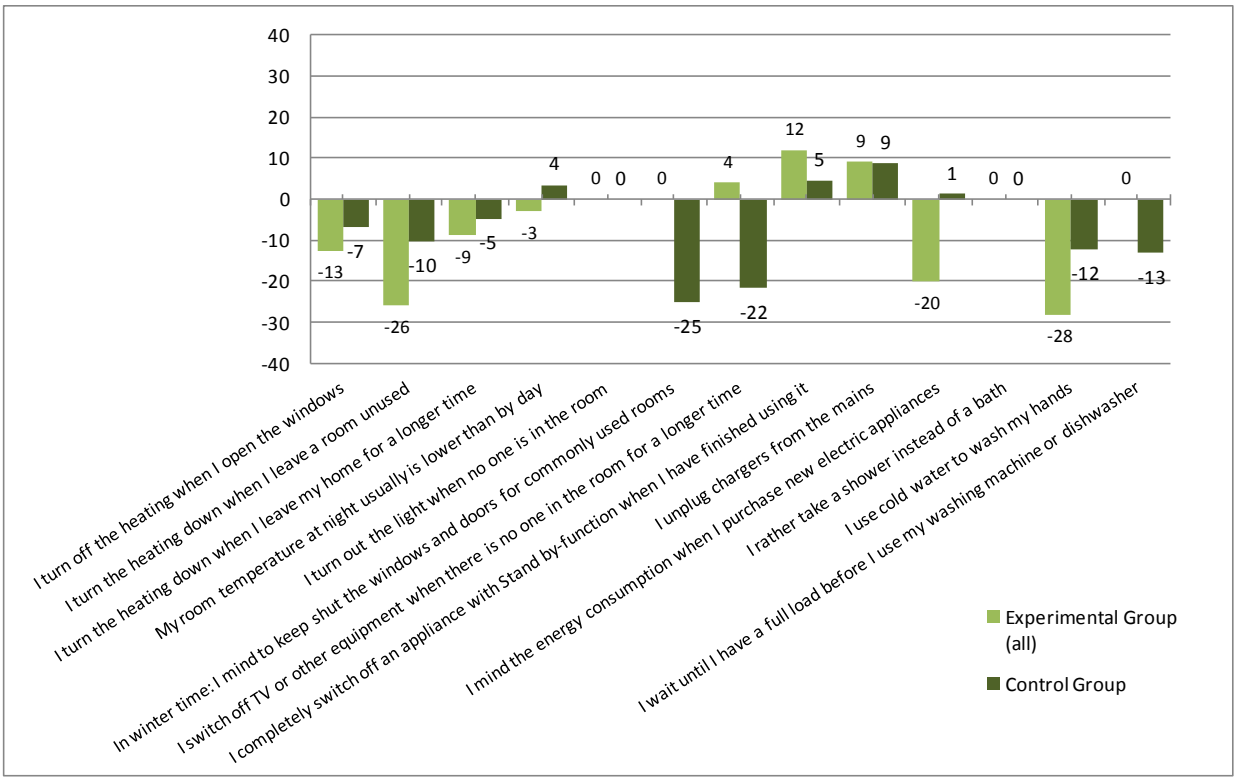


On the other hand there are some behaviour patterns – mainly related to heat energy – that show negative trends. In the case of turning the heating down when leaving a room unused an at least partly explanation could be that there are some missing values of that statement at final stage which can lead to a biased result. In addition to that, not so long ago there was the general idea in Spain that the heating system should not be touched during winter when the temperature was set on a certain temperature. People thought that changing the temperature would result in an increased consumption. Many tenants might still keep this in mind. That is also applicable for turning off the heating when ventilating which can be secondly influenced by the weather conditions. Especially if tenants mainly ventilate their rooms by opening windows widely at times

[56] Answer categories „not applicable” and “don’t know” were coded as missing. Due to the low number of respondents (N=2), the statement about tumble drying clothes is excluded from the analysis.

(but not if they leave them open or ajar for longer time periods) this would be a strong explanation.[57] The following analyses will shed light on this assumption.[58]

Figure 4.4.21: Changes of ecological behaviour of experimental group and control group tenants
(n=20-25 in exp. group and 35-41 in control group due to missing values[59]; pre-post comparisons; percentage point differences of answer categories "strongly agree and rather agree")



As figure 4.4.21 shows, there are mostly similar trends in experimental and control group. This suggests a general trend that probably accounts for behavioural changes besides the RUAS services and which is very likely related to the increasing energy prices in the past years and the impression of tenants to be unable to reduce energy costs with own effort. In addition to that and according to the pilot site manager, tenants of the control group have very low incomes. That probably makes them more conscious of their energy consumption and the relevant behaviour. [60]

Behaviour patterns that show positive results and seem to be influenced at least partly by the RUAS services are "I mind to keep shut windows and doors of common used rooms in winter time"; "I switch off TV or other equipment when there is no one in the room" and "I completely switch off an appliance with Stand by-function". The proportion of tenants with reported good ecological behaviour remains on high level or further improves in the experimental group, but shows a negative resp. less positive trend in the control group.

These results are confirmed by the difference between experimental group and control group at final stage. As figure 4.4.22 shows, within the experimental group there are much more tenants

[57] This information was provided by the pilot site manager. Another assumption was that the question about ventilation and heating behaviour seems to be strange for the tenants because they normally do not lower temperatures when ventilating rooms. So this question might also produced „strange answers".

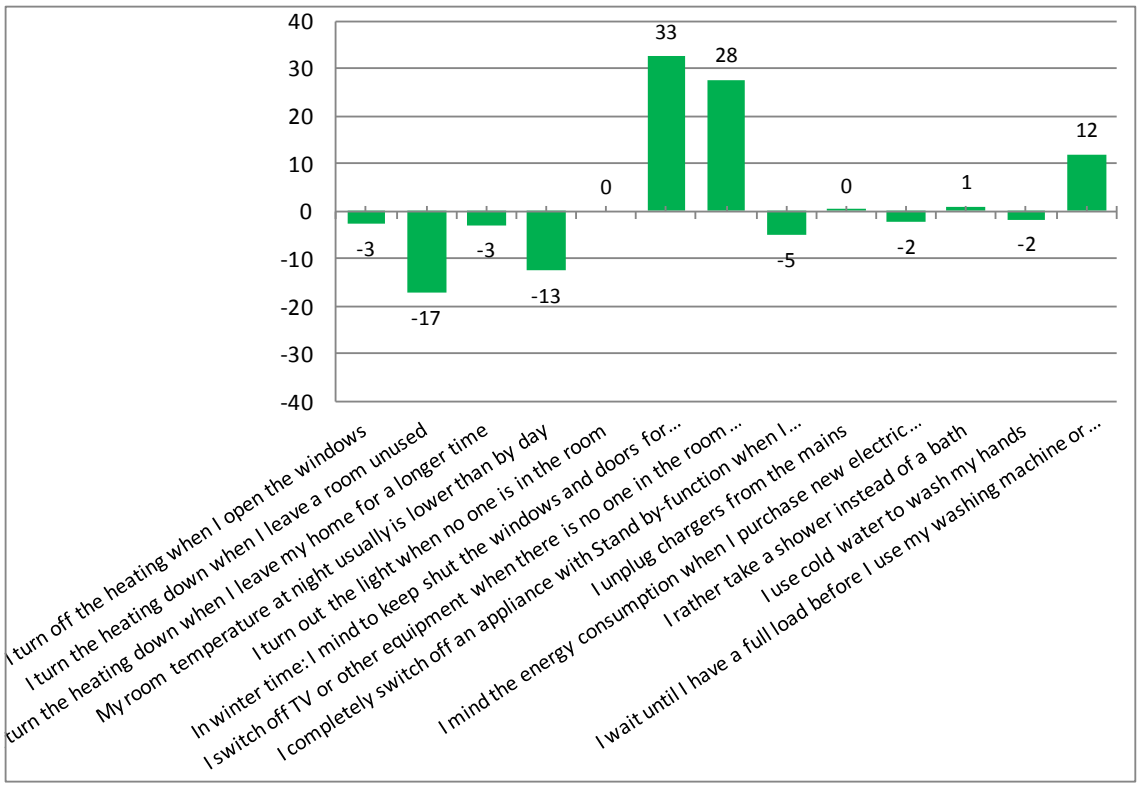
[58] See chapter about ventilation behaviour.

[59] Answer categories „not applicable" and "don't know" were coded as missing.

[60] Despite of many missing values, this can be confirmed by the survey data: 14% of the experimental group tenants, but 19% of the control group tenants have a very low monthly net household income of less than 500 EUR.

with a pro-ecological behaviour when turning out the light when no one is in the room, keeping shut windows and doors of common rooms in winter time and using cold water for hand-washing. The group differences on percentage basis related to these three items are 33%-points, 28%-points and 12%-points. Seeing the fact that these differences were not as high at baseline stage, they can be interpreted as positive result mainly caused by the RUAS services. At the same time, at final stage fewer tenants of the experimental group completely switch off appliances with Stand by-function than in the control group, but that difference decreased during the use of the services. That's why this can also be interpreted as a positive influence of the RUAS services.

Figure 4.4.22: Differences between experimental group and control group at final stage
(n=20-41 due to missings[61]; percentage point differences for answer categories "strongly agree and rather agree")



Ventilation behaviour

The following figures show the ventilation behaviour of both groups at final stage. A pre-post comparison is not possible due to a question modification in the final survey. That's why the analysis is based on tenants who at least participated in the final survey.

It becomes obvious that the experimental group shows more often ecologically orientated ventilation behaviour than the control group. The tenants of the experimental group mainly act best when opening windows widely at times or use the second-best option and leave windows ajar at times. In contrast, this is not applicable for control group tenants who mainly leave windows ajar at times respectively often or all the times. Even if the initial situation prior the service is unknown, the differences are large enough and consistent with different rooms that they serve as good argument for an influence resulting from the tenant portal (even if it cannot be proofed against further influences).

[61] Answer categories „not applicable" and "don't know" were coded as missing.

This may also explain the negative trend of the experimental group related to turning off the heating when opening the windows. Due to the fact that tenants more often open windows widely at times, they probably do not see a need for turning off the heating (as already mentioned above).

However, this finding is only partly consistent with the result of the separate question about the duration of leaving windows ajar. In that case no meaningful difference between control group and experimental group is obvious. In both groups more than three quarters do not leave certain windows ajar over a period of at least 1 hour a day (26 out 35 tenants in experimental group; 45 out of 56 tenants in control group). But because many tenants do not know the exact time period of keeping windows ajar, this result should not be over-interpreted.[62]

Figure 4.4.23: Ventilation behaviour of exp. group tenants in winter time (final stage)
(n=16-34 due to missing[63]; percentage)

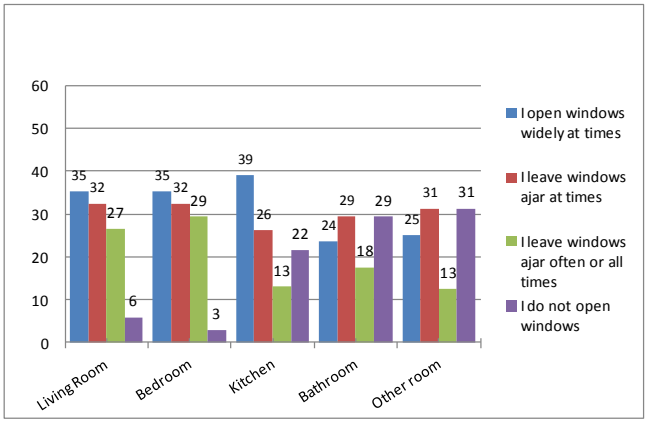
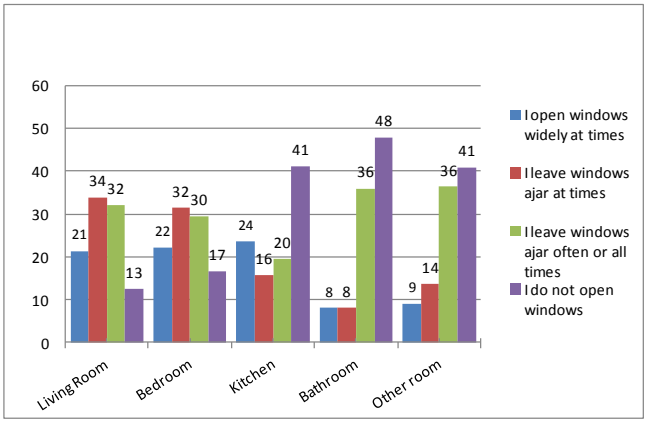


Figure 4.4.24: Ventilation behaviour of control group tenants in winter time (final stage)
(n=22-56 due to missing[64]; percentage)



Room temperature and use of air conditioning

Considering the room temperatures in winter time, the experimental group reported on indoor temperatures of – generally recommended – 20°C on average in much used as well as in little used rooms already at baseline stage and again at final stage. As a consequence, there is no or only limited potential for heat energy savings. Approximately the same results can be found in the control group.

An air condition is available in three respondent households only. That's why an analysis is not useful.

Retrospective and prospective behaviour

The retrospective question about changes of the tenants' ecological behaviour as the consequence of the portal use shows mixed results. Three of the ten active portal users agree with the statement that they changed their behaviour, six disagree and one tenant doesn't know.

The intention of the active users to conserve heat energy, electricity and water in future is rather high. In each category there are six tenants who intend to save energy in future.

[62] According to the pilot site manager, tenants surely know if and how they open windows, but they don't remember exactly the duration.

[63] Answer category „not applicable/no window in room" was coded as missing.

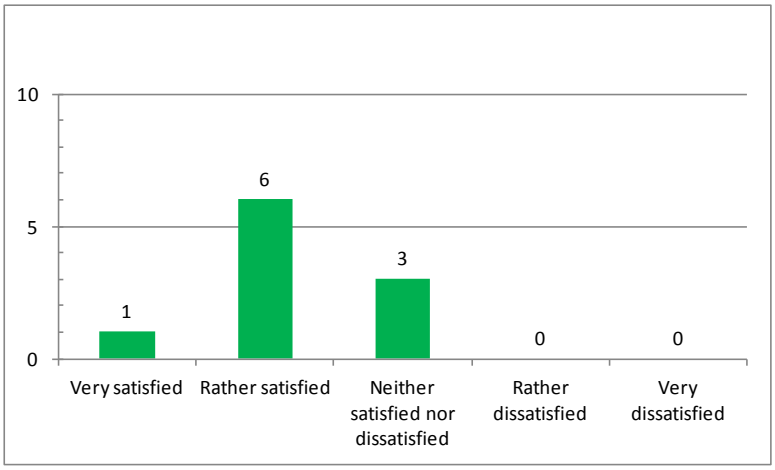
[64] Answer category „not applicable/no window in room" was coded as missing.

In summary, it can be stated that the RUAS services show some influences on tenants' behaviour. In many cases pre-post comparisons do not deliver positive results because of the low potential for improvement resulting from high agreement levels already at the baseline stage. However, positive trends resulting from the RUAS services can be found for behaviour patterns related to all resources.

Satisfaction with tenant portal

The following figure shows that the active portal users mostly are satisfied with the tenant portal in general. One out of ten tenants is very satisfied, six tenants are rather satisfied. Furthermore, there isn't any unsatisfied tenant. However, three tenants are still undecided which means that there is some potential for further improvements of the portal. The only problem mentioned once was a problem with the Wifi connection.

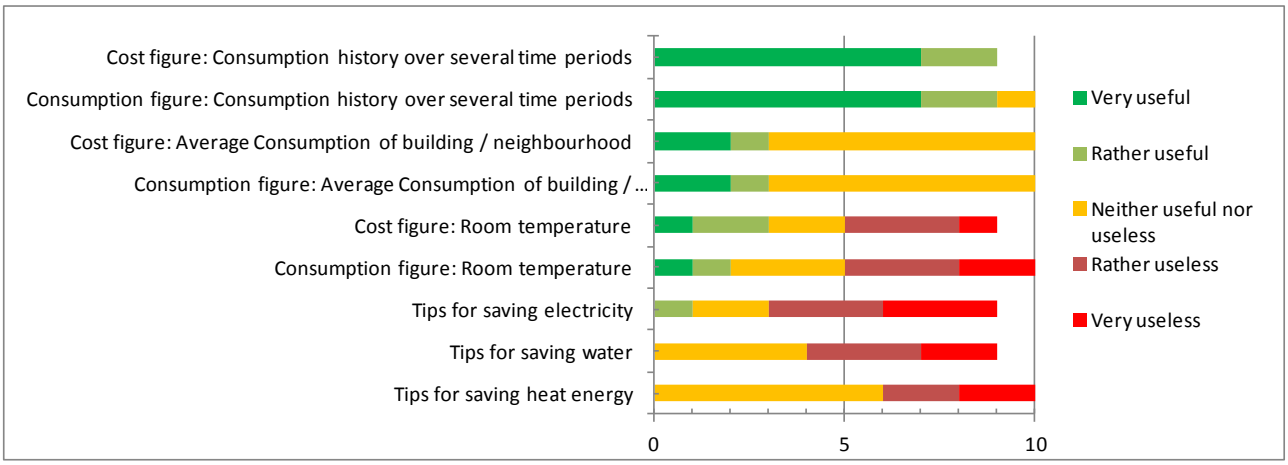
Figure 4.4.25: General satisfaction with tenant portal
(n=10; frequency)



Question: How satisfied are you with the services of the tenant portal in general?

The following figure regarding the usefulness of the information presented in the tenant portal shows quite different results for the single aspects. It provides a differentiated view on statements related to cost and consumption figures.

Figure 4.4.26: Usefulness of information presented in the tenant portal
(n=9-10 due to missings; frequency)

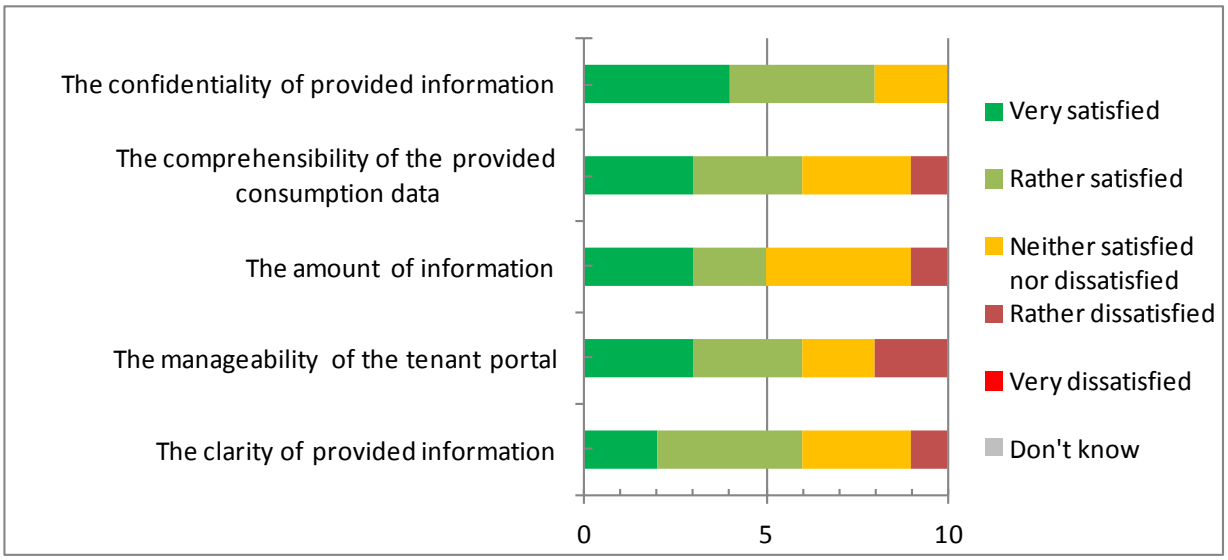


In general the assessment of the usefulness is not directly linked to cost figures or consumption figures, but it depends on the information given within the figures. The consumption history related to several time periods appears as most useful information with regard to consumption and cost

figures equally. Seven tenants consider it as very and further two persons as rather useful information. In the second position there are comparative consumption figures and cost figures regarding the average consumption of the building/neighbourhood which is for two tenants very useful and for another tenant rather useful.

Of minor interest are cost and consumption figures in relation to the room temperature and tips for saving energy in general. A reason could be that tenants already behave in the suggested manner (see the section above), so that saving tips seem to be not very helpful in order to reduce energy consumption and costs even more. In addition to that, the pilot site manager assumed the occurrence of satiation. The tenants received continuously a lot of tips by using different channels and also tested them in the course of time. Probably they are now a bit "tired". This assumption can be underlined with the above described results of the mid-term survey when the respondents judged the energy saving tips mainly as useful and reported on giving them a trial.

Figure 4.4.27: Satisfaction with handling of the tenant portal
(n=10; frequency)



The satisfaction with the handling of the portal is rather high. In particular the tenants are satisfied with the confidentiality of the provided information. Predominantly positive ratings apply to the comprehensibility of the consumption data, the manageability of the tenant portal and the clarity of information. Related to the amount of information provided, four tenants are neither satisfied nor dissatisfied. In general, the answers suggest already a quite high quality level of the tenant portal.

Prospective portal use and willingness to pay

Nine out of ten tenants intend to use the portal regularly also in future which shows again the high appreciation of the tenant portal. Thereof two tenants are willing to pay a certain amount (1 resp. 5 EUR per month) for an energy monitoring device that is comparable to the tenant portal.

Evaluation of further RUAS features

Manresa added further questions to the questionnaire in order to evaluate some aspects beyond the tenant portal that are part of additional RUAS services. Furthermore, light is shed on the motivation of control group tenants to receive similar services.

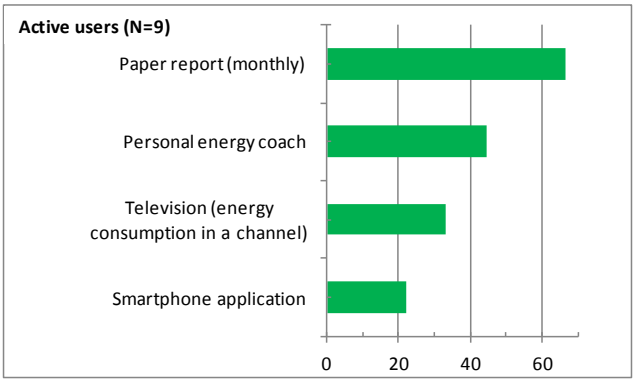
Evaluation of BECO

Five out of nine active users assess the character BECO (the above described CI mascot appearing in all materials related to the awareness service) as helpful for paying attention to the posters located in the common areas. Two tenants consider BECO as not helpful, further two tenants are undecided.

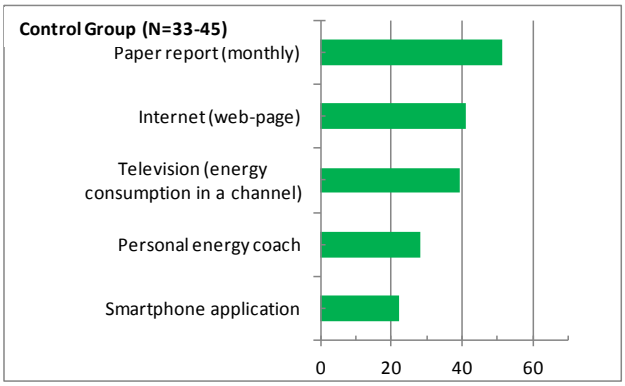
Evaluation of different feedback media

The active users were also asked whether they invested more time in consulting the web portal service or in reading the monthly paper reports. The result shows that six out of nine tenants invested more time in the paper reports, the remaining three respondents in the portal. This corresponds to another finding that also six out of nine tenants judge the paper report as very valuable, whereas only three respondents agree with that related to the web portal. This suggests that a printed report could attain more attention. Tenants who don't make use of the portal may benefit a lot from the RUAS services.

Figure 4.4.28: Relevance of means for providing consumption feedback (percentage for full/rather agreement; high/rather high interest)



Survey Question: Will you check your consumptions more often if the information was delivered to you via…
(scale from 1=fully disagree – 5=fully agree).



Survey Question: In case you were interested in a service that provides you nearly real-time information about your consumption, could you please evaluate from 1 to 5 the interest in the media in which you will more likely appreciate having this type of information
(Answer categories from 1=not interested – 5=very interested).

A high relevance of paper reports can also be observed when asking the active users about the mean which could contribute to check their consumption more frequently. The same applies to the control group when asking for the mean of consumption feedback they interested in. In both groups paper reports range at the first place by far. Control group tenants are also often interested in an internet page, followed by a television channel and a personal energy coach. For the active users a personal energy coaching is more relevant than a television channel. Of minor interest in both groups is a smart phone application.

General interest of control group tenants in receiving a feedback service

The tenants of the control group have also been asked for their general interest in receiving a feedback service. They stated a rather high interest. More than half of the 57 respondents are very or rather interested in such a service including 28% very interested tenants (n=16) and 26% rather interested tenants (n=15). This shows that extending the services to further tenants seems to be a worthwhile option.

In summary, the high satisfaction of the active users shows a noticeable success of the tenant portal. Rather low satisfaction rates related to the provided energy saving tips are very likely due to the already high levels of ecological behaviour which limit the potential for improvement. Besides of that, the Manresa pilot site uses the means (web portal and paper reports) that are preferred by active users as well as by control group tenants. It seems to be worthwhile to extend the services to further tenants as their interest is rather high.

4.4.4 Results of combined analysis

In Manresa the combined analysis of survey data and consumption data includes heat energy, cold water and electricity consumption. It will give further details about the water consumption per capita for the subsample of tenants who reported the size of the household in the survey.

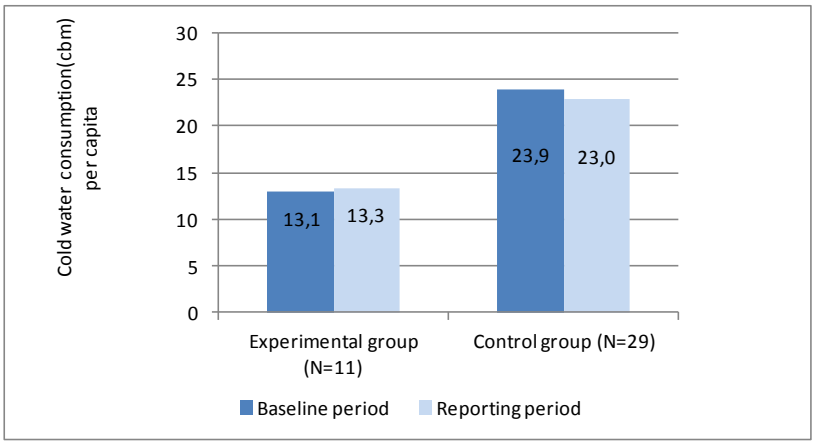
As the ecological awareness of tenants in Manresa was already very high already during the baseline period, further analyses focus on the behaviour of tenants that is in general more directly linked to the energy consumption.

One further target is to give further explanations (besides the already low consumptions at baseline period; see section 4.4.2) for the increased consumption of the experimental group with relation to electricity consumption. As in the survey analysis (see section 4.4.3) remarkable differences between experimental group and control group were noticed, the influence of socio-demographic characteristics on the energy consumption will be also examined.

Water consumption per capita

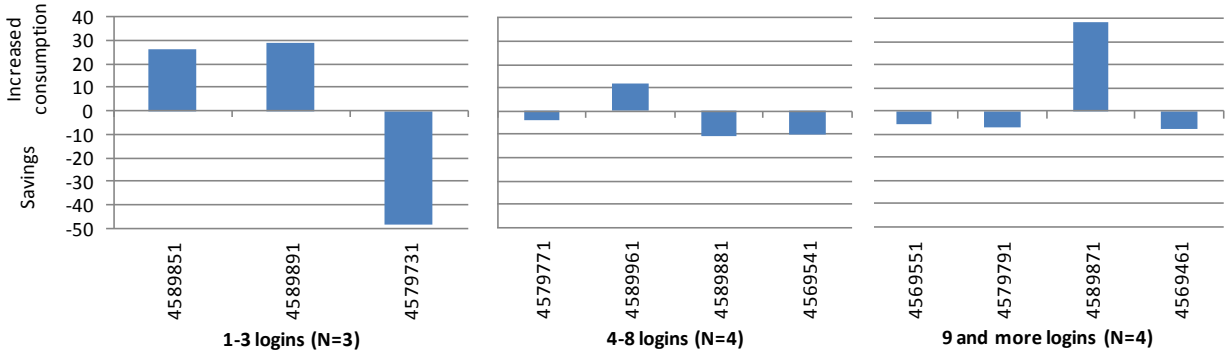
The household size is only known for respondents of both survey stages. Related to this subgroup the average consumption per capita is shown in the following figure. It becomes obvious that there are no major differences in the consumptions of baseline and reporting period. Tenants of the experimental group consumed approx.13 m^3 water in both baseline and reporting period. Tenants of the control group consumed much more cold water: 24 m^3 in the baseline period and 23 m^3 in the reporting period. This means that the services did not lead to savings in water consumption. But this is very likely due to the already comparably very low consumption of the experimental group in the baseline period which limits further (major) savings. On average the tenants of the experimental group showed a consumption increase of 1%-point, while the control group consumed 1.8%-points less water than in the baseline period. This result is consistent with the findings reported in section 4.4.2.

Figure 4.4.29: Average cold water consumption per capita related to experimental and control group



The detailed consumption analysis (section 4.4.2) described a positive influence of the portal use frequency on water consumption during the reporting period. The following figure shows this relation based on the water consumption per capita. Despite the very low sample sizes, on the basis of the consumption per capita there are also hints for a better performance of medium and heavy users visible. Nearly all medium users (4-8 logins) and heavy users (9 and more logins) achieved savings whereas two of the three weak users (1-3) show an increased consumption.

Figure 4.4.30: Percentage change in cold water consumption related to the portal use frequency



Everyday ecological behaviour and energy consumption

Electricity consumption

In the following section the ecological behaviour reported at the final survey is analysed with regard to the measured energy consumption of the reporting period.

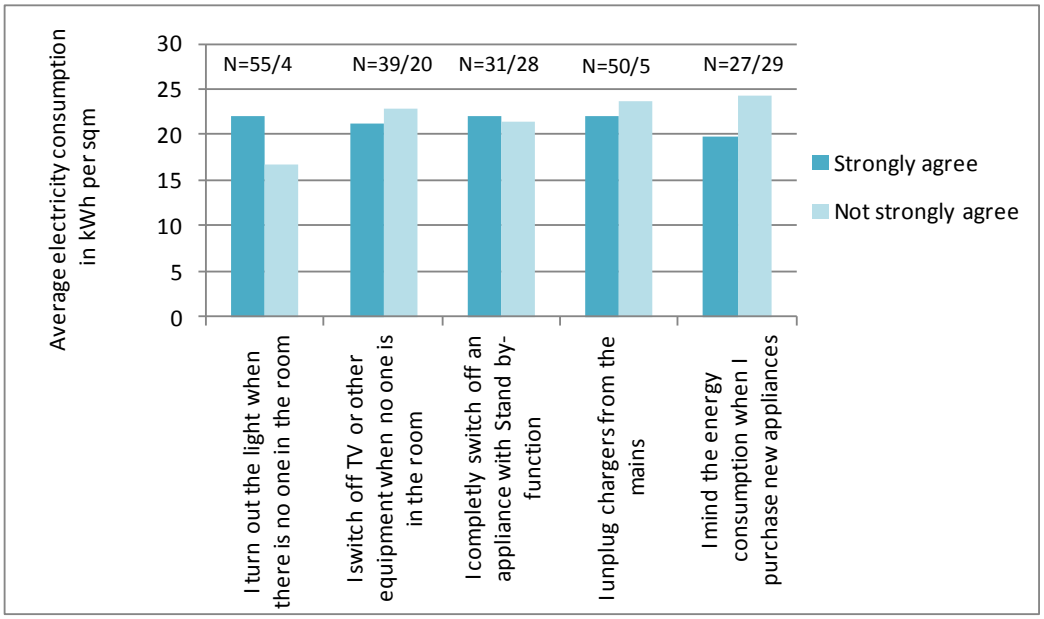
The first part focuses on electricity consumption with available information on the following activities:

- turning off the light when there is no one in the room;
- switching off TV or other equipment when no one is in the room;
- completely switching off an appliance with stand by-function;
- unplugging chargers from the mains;
- to mind energy consumption when purchasing new appliances.

The following figure shows for three behaviour patterns slightly lower consumptions of tenants who strongly agree to the items compared to tenants who do not strongly agree.[65] Two exceptions can be found related to the items “I completely switch off an appliance with stand by-function” and “I turn out the light when there is no one in the room” with nearly no differences or a consumption increase of tenants who strongly agree.

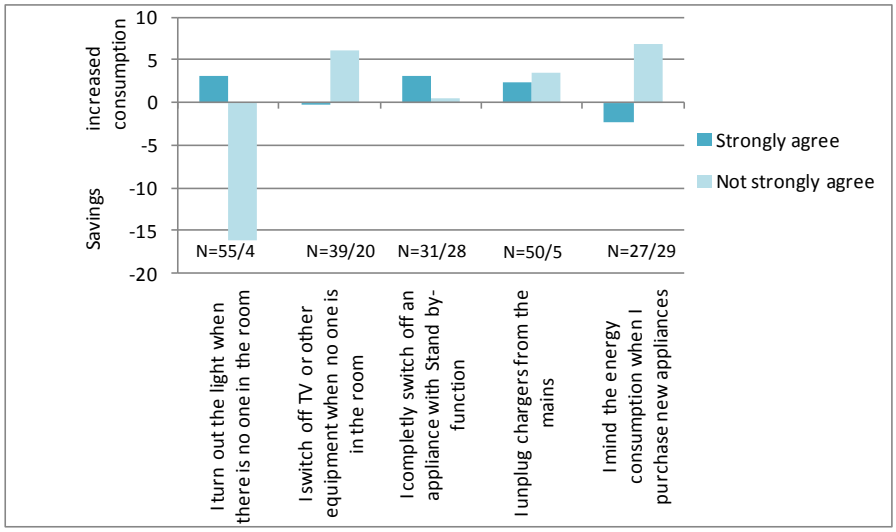
[65] This includes the following answers: I rather agree, I neither agree nor disagree, I rather disagree, I strongly disagree.

Figure 4.4.31: Electricity consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



Due to the small sample sizes the change of behaviour cannot be examined with relation to the achieved savings / increased consumptions. Instead, the ecological behaviour that is reported at the final survey is analysed related to the savings. The following figure shows that the tenants achieved rarely savings whether they behave ecologically or not. The greatest influence of the behaviour on the achieved savings can be found related to the purchase of new electric appliances. This is the aspect which is generally assumed to have the biggest impact on the electricity consumption whereas it is more difficult to achieve remarkable savings with other kinds of behaviour. That's why also further findings can be interpreted as positive developments: Tenants who switch off TV or other appliances when no one is in the room achieved small savings whereas tenants who do not strongly agree to the item show an increased consumption. In addition to that, the increased consumption of tenants who unplug chargers from the mains is somewhat lower than for tenants who do not.

Figure 4.4.32: Percentage change in electricity consumption for tenants with ecological behaviour at final stage



Only for the items "I turn out the light when there is no one in the room" and "I completely switch off an appliance with stand by-function no positive results can be found. It has to be pointed out that

there are only few tenants who do not strongly agree to the item about turning out the light and the result could be biased. Indeed, among the respondents who do not turn out the light when there is no one in the room (not strongly agree), there are two tenants with extremely high savings of 46% and 20%-points. The first one had high electricity consumption during baseline period (34.15 kWh/m^2) and that's why higher potential for savings. However, the tenant does not belong to the experimental group. The other one had already low electricity consumption in the baseline period, but was able to reduce it even more. This tenant belongs to the experimental group and might be influenced by other energy saving tips.

Heat energy consumption

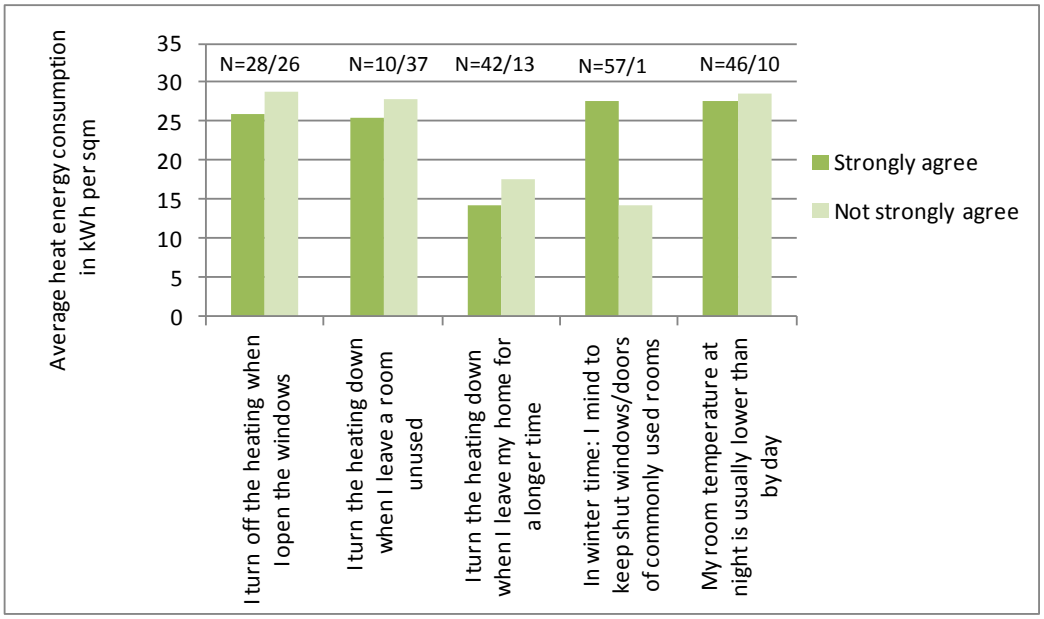
With respect to heat energy, the relation between behaviour and consumption is more obvious than with respect to electricity consumption. Nearly all behaviour statements show an influence on the heat energy consumption. Tenants who strongly agree with

- turning off the heating when opening windows;
- turning the heating down when leaving a room unused;
- turning the heating down when leaving a room for a longer time and
- having a lower room temperature at night than by day

show lower heat energy consumption than tenants who do not strongly agree with these items.

The only exception is related to keeping shut windows and doors of commonly used rooms in winter time. But there is only one tenant who does not strongly agree with this item, that's why the result has to be handled with caution.

Figure 4.4.33: Heat energy consumption (reporting period) of respondents with and without ecological behaviour reported in final survey

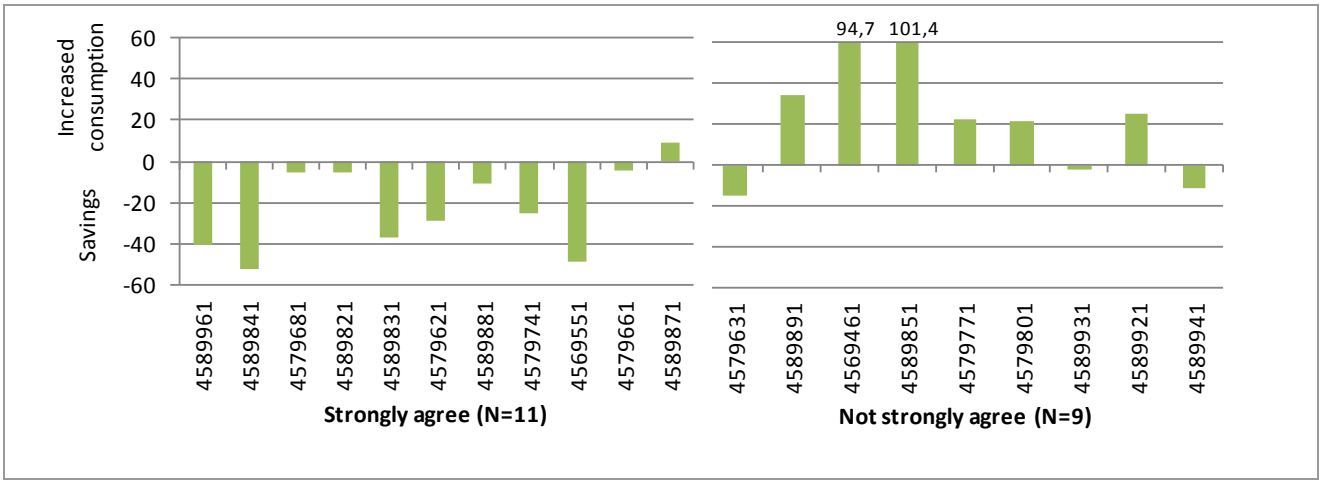


As a pre-post comparison of heat energy consumption is only possible for the experimental group, there are very restricted samples available for examining the relation between ecological behaviour and achieved savings respectively increased consumption. Such an analysis is only useful with regard to the item "I turn off the heating when I open the windows".[66] As the following figure shows, except one, all tenants with reported ecological behaviour (strongly agree with the item) achieved savings. More than half of the savings is higher than 20%-points which is a remarkable level. On the other hand, tenants who do not show an ecological behaviour mostly had an increased

[66] For the other items the number of cases in at least one subgroup is 3-5.

consumption of more than 20%-points. In two cases the increase is even higher than 90%-points. This means that heat energy consumption is strongly related to this behaviour item and it is very useful to address this behaviour in feedback services as provided in the project.

Figure 4.4.34: Percentage change in heat energy consumption for tenants of with and without ecological behaviour: I turn off the heating when I open the windows



Cold water consumption

With respect to cold water consumption one behaviour item is available: “I rather take a shower instead of a bath”.

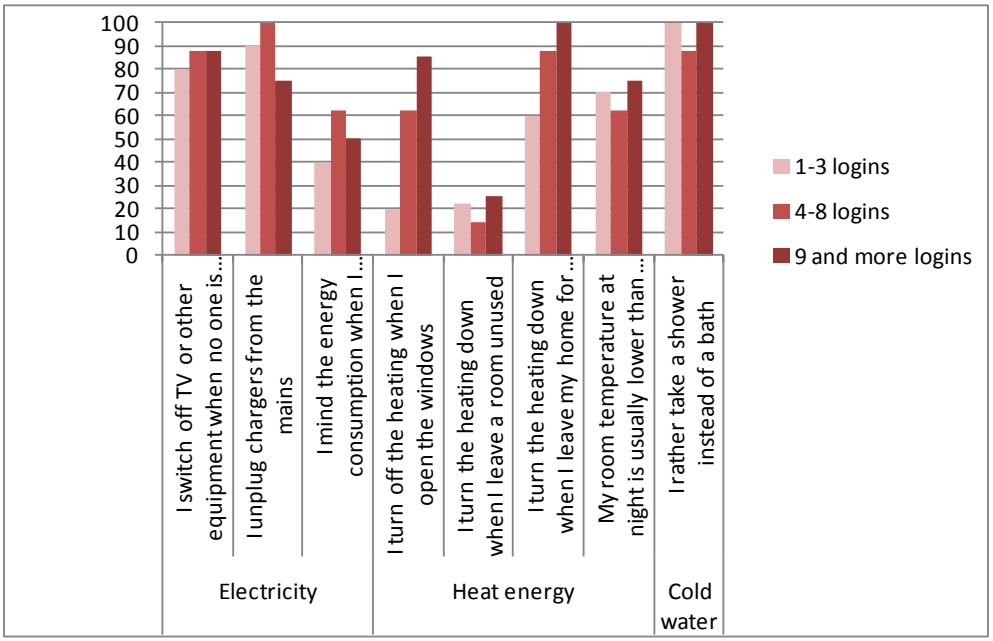
Related to the average water consumption per capita it becomes obvious that tenants who strongly agree with the item consumed more water (19.9 m^3/capita) than tenants who do not strongly agree (17.5 m^3/capita). Examining the percentage changes in cold water consumption per capita there can be found savings of 1.8% for tenants who strongly agree with the item whereas tenants who do not strongly agree show an increased consumption (13.2%). But it has to be mentioned that the results for tenants who do not strongly agree are based on very low sample sizes (n=4 for consumption in reporting period; n=2 for percentage changes of consumption).

Login frequency and everyday ecological behaviour

As all of the tenants in the experimental group logged in the portal, further analyses can be made. It is of interest if the portal use frequency has an influence on the ecological behaviour of tenants. Therefore such behaviour items are considered that – based on the analyses above – showed an influence on the energy / resources consumption and/or savings.

The following figure shows the percentages of tenants who strongly agree with the respective behaviour items related to the portal use frequency. Although the results partly base on very low sample sizes, for most of the behaviour items a positive influence of the portal use frequency can be found. With respect to heat energy and cold water consumption, especially the heavy users (9 and more logins) more often strongly agree to the items than weak users (1-3 logins). With respect to electricity consumption heavy users perform not better than medium users, but medium users are better than weak users.

Figure 4.4.35: Ecological behaviour related to portal use frequency
(percentages for answer category "strongly agree"



In summary, it can be stated that the portal use frequency has an effect on the ecological behaviour of the experimental group tenants. Medium and/or heavy users more often behave in an ecological manner than weak users do. This means that it is quite important to motivate tenants for a regular use of the portal in order to influence their behaviour and in doing so, to achieve a reduction of energy and/or resources consumption.

Socio-demographic profile and energy consumption

Within the survey analysis were found some differences in the socio-demographic profile of the control group and the experimental group. That's why the correlation between socio-demographic information and energy consumption respectively savings is further examined. This is realised related to the available household information (and not related to the individual respondent) which covers:

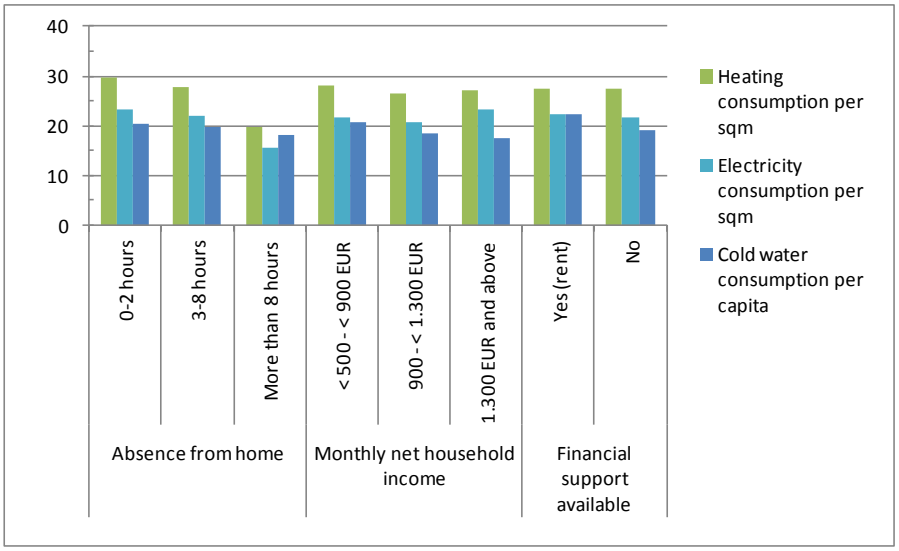
- absence of all household members at a normal weekday,
- monthly net household income and
- financial support by municipality.

The information on the absence from home of all household members at a normal weekday has been summarised to three categories: households with short absence (0-2 hours), medium absence (3-8 hours) and long absence (more than 8 hours). The monthly net household income has been categorised along the terciles of the distribution.

As the following figure shows, the absence from home shows the expected relation: Households with short absence consumed more energy than households with medium or long absence. This is true for heat energy, electricity and cold water consumption.

With respect to the household net income an established assumption is that households with low incomes consume less energy in order to save money than households with high incomes. That cannot be completely confirmed. Only related to electricity consumption there seems to be a correlation because households with high incomes consumed more energy (23.4 kWh/m^2) than households with medium (20.6 kWh/m^2) or low incomes (21.6 kWh/m^2).

Figure 4.4.36: Energy and resources consumption related to social demographic information
(Average consumptions)



Another assumption is that households who receive financial support from the municipality might be less aware of energy saving issues. This can be confirmed for electricity and cold water consumption. With respect to both resources households with financial support consume slightly more resources than households without financial support.

With respect to the achieved savings or increased consumptions, there seems to be a pattern of the availability of financial support and the percentage change of energy consumption. Households without any financial support perform better with regard to heat energy and cold water consumption than households with support. However, this relation cannot be found for electricity. In that case households with financial support saved energy (-5.9%), but household without support consumed more energy (3.3%). It has to be considered that there might be inter-correlations between the household income and the financial support and/or further socio-demographic characteristics that cannot be analysed in detail.

These results partly explain the different performances of experimental and control group tenants related to water and electricity savings respectively increased consumptions because the experimental group receives more often financial support than the control group. As reported within the consumption analysis (section 4.4.2), the control group performed better with respect to water consumption (water: 2.2% increased consumption) than the experimental group (water: 6.9% increased consumption.[67] This means that the worse performance of the experimental group (calculated on the basis of average consumptions) might be partly due to their more frequent financial support. This shows the importance of taking into account socio-demographic characteristics when analysing the impact of energy saving services. Such information provides better explanation why tenants are more or less responsive to such services.[68]

[67] With respect to heat energy a pre-post comparison with control group was not applicable; see section 4.4.1.

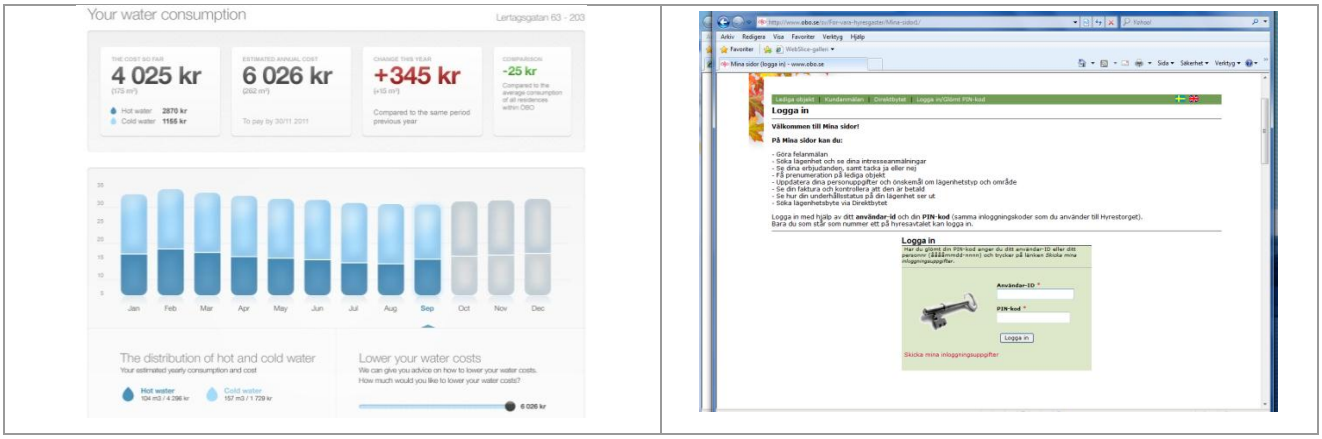
[68] The most appropriate approach would be to carry out such an impact assessment with help of multivariate analyses. However, these kinds of statistical analyses require a larger number of cases.

4.5 Örebro

4.5.1 Background information

Örebro implemented a RUAS as well as a RMS. The RUAS consists of a tenant web portal providing each household with feedback on hot and cold water consumption, its respective costs and a forecast of the estimated annual costs. It is also used for an individual consumption billing which is an innovation due to the fact that the water consumption expenses were included in the rent before. That's why all RUAS dwellings were equipped with meters for hot and cold water. The tenants got a reduction of their rents and after that they had to pay for their water consumption separately. By means of the RUAS, tenants receive now monthly invoices related to their actual consumption. In doing so, all tenants got a rent reduction which should motivate them for the project. In addition to that, the tenant portal provides comparisons with previous consumption periods and with similar dwellings. Furthermore the RUAS offers personalised saving tips and alerts on mobile phone, in the portal or via e-mail.

Figure 4.5.1: Screenshots (before updates) of RUAS tenant portal (left) and RMS professional portal (right)



The RMS serves as a monitoring instrument related to water and heating in order to detect malfunctions and to address maintenance warnings directly to the staff. It is also used for limiting the – also measured – indoor temperatures at a maximum level of 21°C.

Both services started operation in October 2012. In order to analyse comparable time periods, the reporting period was defined identically to the available baseline measurements. In doing so, both comparison periods cover in each case 10 months: baseline period: Jan 2012- Oct 2012; reporting period: Jan 2013 to Oct 2013. That allows pre-post comparison based on the analysis of the evolution of the consumption figures resp. the in tenant surveys reported behaviour patterns/attitudes before and after the implementation of the service.

RMS was operated in all pilot buildings. The RUAS was originally addressed to a sub-group of tenants, while another sub-group should be part of a pre-defined RUAS control-group (see following table). However, RUAS was installed in all dwellings, but in the control group it was not started and therefore the tenants have not been informed about the portal. But the use of the web application was not blocked for tenants of the control group.[69] Some of those tenants informed themselves – e.g. in talks with their neighbours – about the offered consumption feedback via tenant portal and partly used the tenant web portal. That's why the planned quasi-experimental

[69] As the RUAS was realised as one additional part of the already existing web site of the housing provider, the tenants had access to the RUAS by using their passwords of that general web site. This approach made it very easy for the tenants of the experimental group to access the portal which can be seen as great advantage, but – as mentioned – it also allows access for tenants of the control group.

evaluation design related to water could not be realised. Nevertheless, a user/non-user comparison is possible (see detailed analysis chapters).

Table 4.5.1: Basic population of dwellings in the two experimental setups

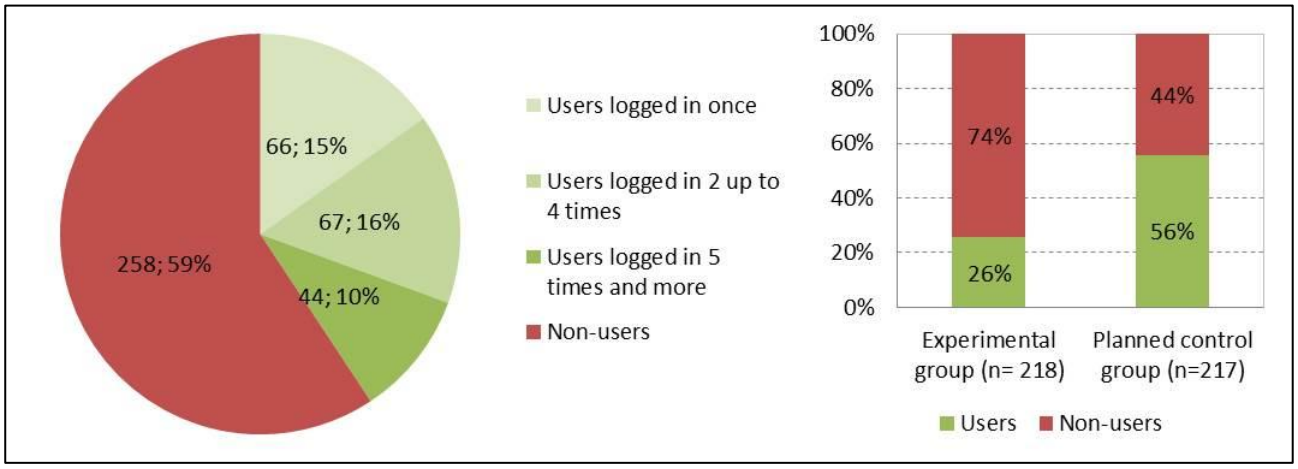
Group Status	Top Setup*	Medium Setup**	Total
Experimental group RUAS	x		
Control group RUAS		(x)[70]	
Experimental group RMS	x	x	
Dwellings with measurements	218	217	435

* Drottniggatan no. 35 (n=16) + 37 (n=16); Palsbodagatan 13 (n=12); Örnsköldsgatan 149 (n=15) + 151 (n=15); Björkallén 56+58+60+62+ 64+66 (each n=1); Rostastrand 35+37+39+41+43+45+47+ 49+ 51+53+55+57 (each n=1), Varbergagatan 7 (n=6) + 8 (n=9) + 9 (n=6) + 10 (n=5) + 11 (n=5) + 12+13+14+15+16+17+18+19+20 (each n=6); Restalundsvägen 26+28 (each n=13) + 30 (n=15).

** Drottniggatan no. 33 (n=16); Palsbodagatan 15 (n=12), Örnsköldsgatan 147 (n=15); Björkallén 26+28+30+32+34+36+38+40+42+44+ 46+48+50+ 52+54 (each n=1), Varbergagatan 1+2+3+4+5+6+27+28+29 (each n=6) + 37+38+39 (each n = 8) + 57 (n=7) + 58+59 (each n=8); Restalundsvägen 24 (n=15) + 32+34 (each n=13) + 36 (n=19).

The tenant recruitment based on a variety of activities. Tenants were invited to participate in tenants' events and received several newsletters. In addition to that, articles in the tenants' magazine and posters in the staircases informed about the project. Tenants were also provided with instructions and training about the web portal use. In general all tenants involved received relevant information but Örebro especially focussed on high consumers as – for example – families with many children (for further details see D.5.2).

Figure 4.5.2: Total number of RUAS users and non-users (left) and distribution in experimental and originally planned control group



Tenants who were interested in the RUAS and that's why logged in the web portal were counted as users. Those who didn't log in were counted as non-users. The analysis showed that 177 of the total number of 435 tenants (41%) used the RUAS more or less regularly – in a range from once up to 116 times in the observed 10 month reporting period. The average portal use frequency was 5.7 times. A surprising result was that the tenants belonging to the properly planned control-group showed a higher interest in the RUAS than the original experimental group. They more often became users (56%) than the others (26%).

One reason for this is that the tenants of the control group knew that they were supposed to start to pay for their actual consumption after the BECA project. Due to this they had a good incentive to learn more about their behaviour. Tenants in the experimental group also received information

[70] As explained in the text the control group approach could not be realised as planned.

about their consumption by the rental coupon. But the control group tenants didn't. This is probably the main reason why so many control group tenants used the portal – they had no other opportunity to get the consumption information.

4.5.2 Results of consumption analysis

In Örebro the consumption measurements were related to heating (district heating; including hot water heating) and hot resp. cold water on a monthly basis. Heat energy could be measured at building-wise level only, while for water dwelling-wise data were available.

Table 4.5.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	building-wise
Hot water	m^3	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. Related to heating in fact all ten pilot buildings could be included, but due to the only building-wise measurements a change of tenancy could not be taken into account. Actually Örebro has a comparably high tenant fluctuation. Related to water in total 147 dwellings had to be excluded from the analysis due to a change of tenancy in the project duration. Further 221 dwellings could not be considered caused by a lot of missing data as a consequence of serious problems with the meters. Another reason for the missing data is that the refurbishment resp. new construction of buildings was not ready in time. That's why many dwellings were occupied during the baseline period.

In total 67 dwellings (15%) remained in the study of water consumption.

Table 4.5.3: Overview of the number of buildings and dwellings involved in the Örebro pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Örebro	10[71]	435	Heating: all 10 buildings Hot water: 67 Cold water: 67	Hot and cold water: 368 (85%; change of tenancy: 147; missing values due to a massive failure of the metering equipment: 221)

Global results

The calculation of global savings following a pre-post comparison led to the results shown in the following figure. The tenants saved in total nearly 940 thousands kWh heat energy, more than 750 m^3 hot water and about 1.4 thousands m^3 cold water. These savings are far above expectations (expected savings: heating 4-6%, hot water 22%, cold water 7%).

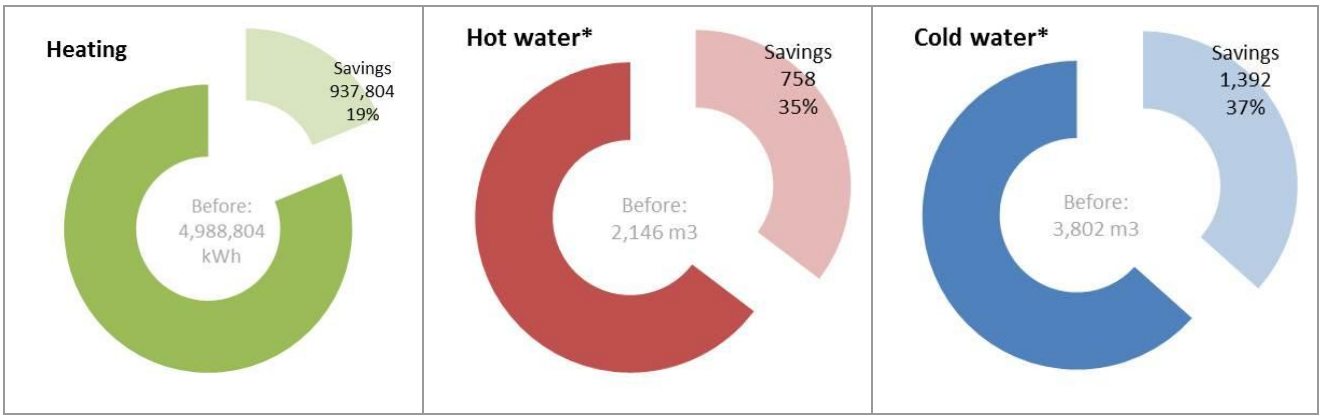
Especially the limitation of the indoor temperature of a maximum of 21°C seems to be a major reason for that immense reduction of heat energy consumption. In addition to that, many of the houses included in the BECA project were newly refurbished. It took some time to optimise the heating systems in the houses. That means that the heat energy consumption during the baseline period could have been too high. This is also one reason for that big saving. Furthermore it has to

[71] A building is defined by its street name and means in the present case a housing block covering multiple house numbers/entrances (see list related to table 4.5.1).

be mentioned that the hot water savings influenced that positive result because of the included hot water heating in the heat energy consumption values in Örebro.

Related to hot and cold water the big saving effect of an individual accounting system became obvious which was newly implemented within the BECA project. The former all-inclusive prices for water in the rent motivated tenants to consume resources more careless. The billing of actual individual consumptions raised their awareness because each cubic meter of water saved implies real saved costs. That was not applicable for the former flat rate.

Figure 4.5.3: Overview of global results of the experimental group in Örebro



* (n=67)

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

Table 4.5.4: Overview of global CO_2- and cost savings of the experimental group in Örebro

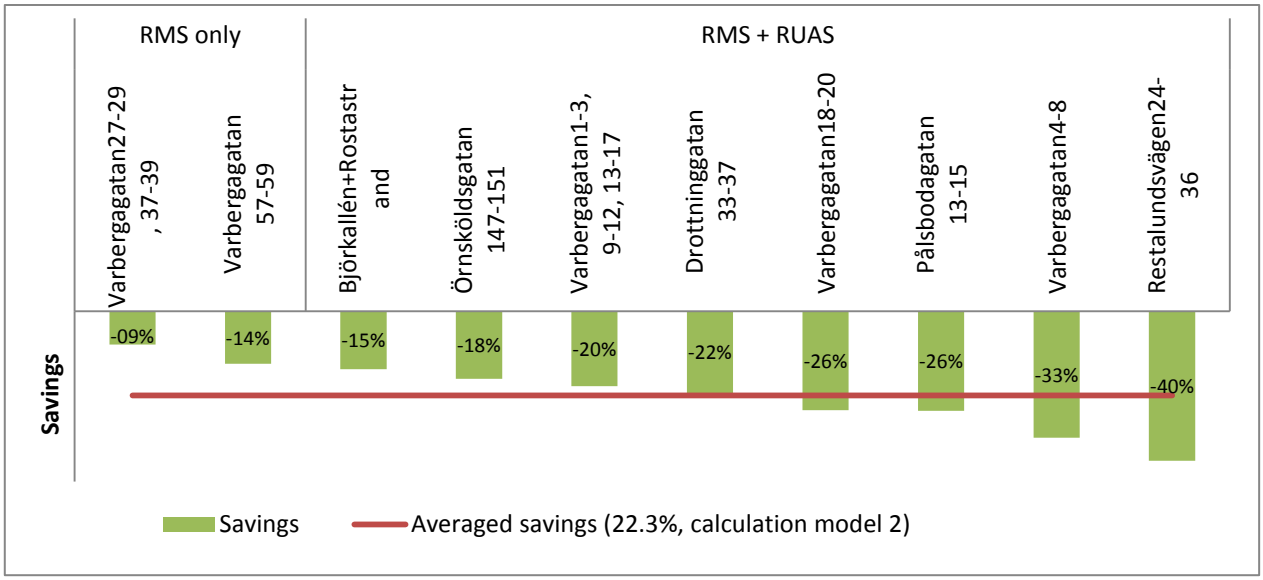
Energy /resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy[72]	0.100 kg CO_2/kWh	93,780	0.07 €/kWh	65,646
Hot water	n/a	n/a	4.55 €/m^3	3,449
Cold water	n/a	n/a	1.10 €/m^3	1,531
Total		**93,780**		**100,626**

[72] Related to district heating the used fuels in process can differ. That's why the emission factor is on average. Hot water heating is included here.

Heating

All buildings operated with RMS achieved significant heat energy savings. The following figure further shows that each single building carries weight to a different degree related to the achieved global savings. There are four buildings with above-average savings of 26% up to nearly 40% reduced heat energy consumption.

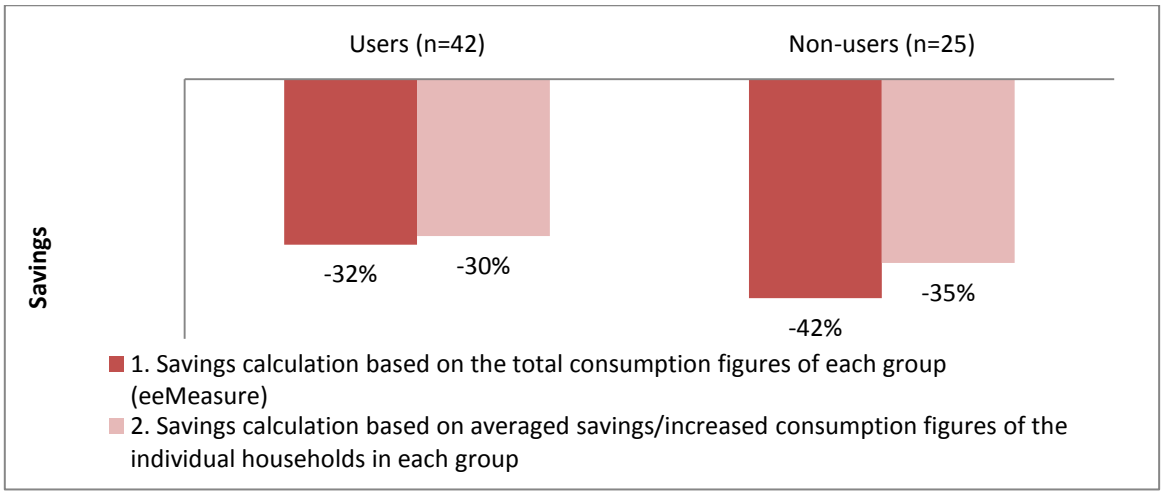
Figure 4.5.4: Percentage change in heating consumption related to the several buildings



Hot water

Both used calculation approaches assessed that RUAS users as well as non-users achieved immense saving results related to hot water consumption. The non-users achieved even better results, but the difference between both groups is statistically not significant[73]. As above already described, an explanation for the savings and the better performance of the non-users is the fact that the tenants knew that they are supposed to pay for their actual water consumption after the BECA project.

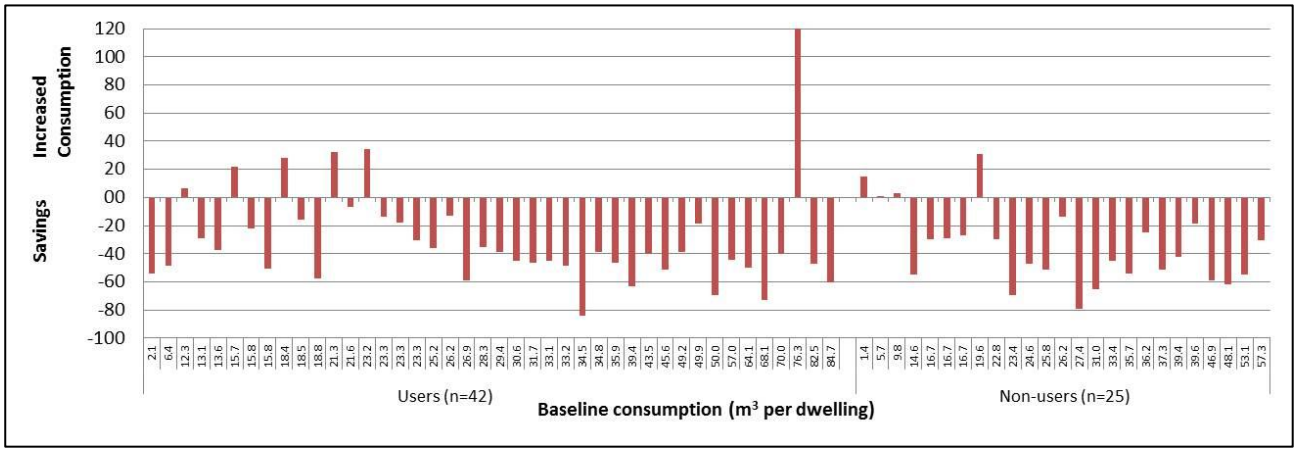
Figure 4.5.5: Percentage change in hot water consumption related to RUAS users and non-users



[73] Analysed by t-test related to the individual savings in both groups

The divergence between both calculation models is again due to a simply mathematical explanation of different weights individual households carry in the one or the other calculation approach. In the present case, that is especially relevant for the group of non-users, where two households with low absolute baseline hot water consumption had a comparably large increase in relative figures which led to a comparably smaller averaged saving result using calculation model 2. Nevertheless, the measured consumption values seemed to be realistic. That's why these households were not excluded from analysis.

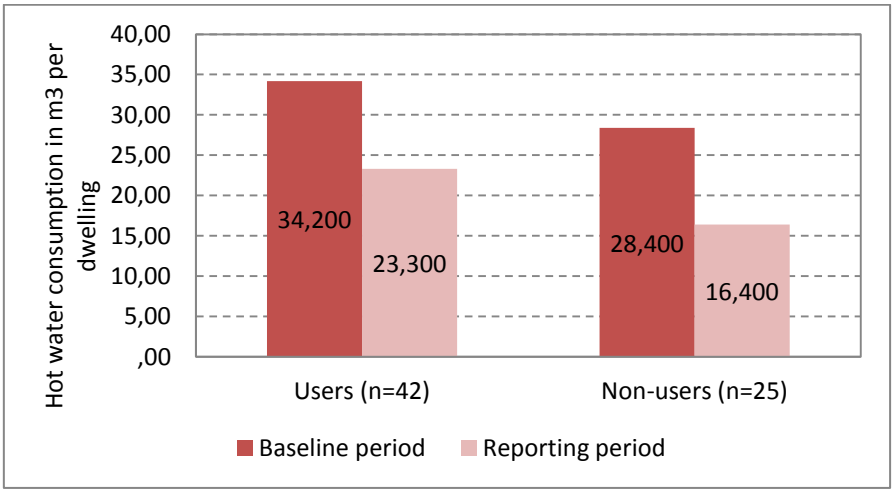
Figure 4.5.6: Savings resp. increased consumption per household (in %) related to the baseline hot water consumption (in m³/dwelling)



Due to missing information about the household size, which is not reliably known in Örebro, the following overview shows the average hot water consumption in m^3 per dwelling. That means that the findings are subject to considerable uncertainty. In contrast to heat energy consumption, where the household size is not as important, the number of persons in a household has an important influence on water consumption. In the combined analysis (section 4.5.4) this is further examined for a subgroup of tenants.

By comparing the dwelling-wise data, RUAS users started at higher consumption level compared to the non-users, but both groups achieved similar reductions: Related to the 10 month observation period the RUAS users reduced their hot water consumption by 10.9 m^3, the non-users by 12 m^3 per dwelling on average.

Figure 4.5.7: Average hot water consumption in m³ per dwelling related to RUAS users and non-users



86% of the RUAS users achieved savings. On average they reduced their hot water consumption by nearly 42% which is very similar to the non-users. In contrast, six user households (14%) had an increase of 40% on average, while for a similarly small part of the non-users their hot water consumption increased by 13% only.

Table 4.5.5: Percentage of dwellings with hot water savings/increased consumption and correspondent average figures related to RUAS users and non-users

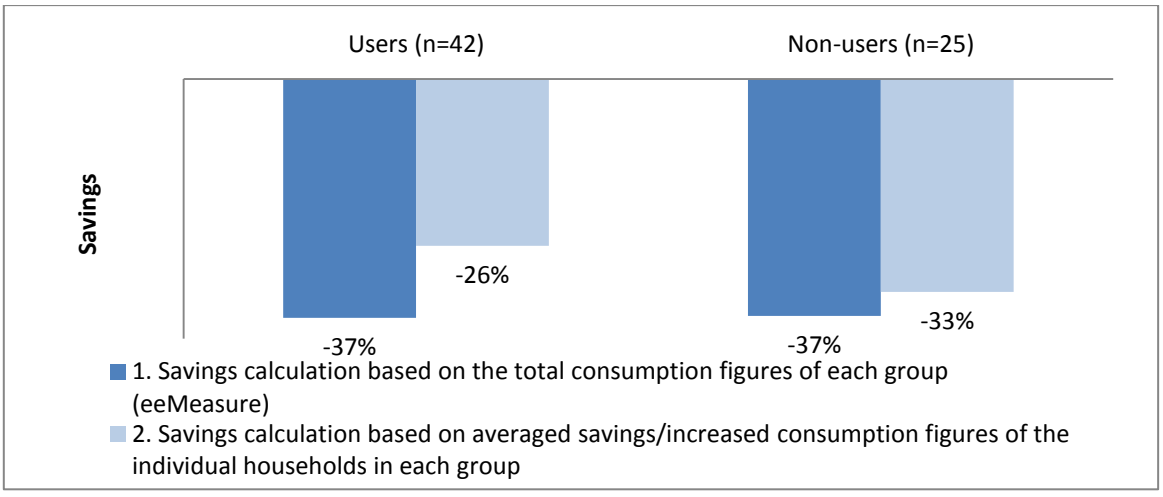
	Users	Non-users	Exp. Group in total
Absolute number and percentage of dwellings with savings	36 (86%)	21 (84%)	57 (85%)
Average savings of dwellings with savings	-41.9	-44.6	-43.0
Absolute number and percentage of dwellings with increased consumption	6 (14%)	4 (16%)	10 (15%)
Average increased consumption of dwellings with increased consumption	+40.5	+12.6	+29.4

As already mentioned above, the monetary stimulus (which is new for the Örebro pilot tenants) seems to be the main motivation to save hot water in order to save money. That's why also non-users of RUAS achieved large consumption reductions. Nevertheless, especially the high consumers (who were the primary target group for RUAS) felt addressed by the RUAS due to its offered support and saving tips.

Cold water

Both calculation approaches assessed, that RUAS users as well as the non-users achieved immense saving results related to cold water consumption. A statistically significant difference between both groups could not be verified[74]. An explanation for the good performance of also non-users is again the announced change of the billing after the BECA project.

Figure 4.5.8: Percentage change in cold water consumption related to RUAS users and non-users

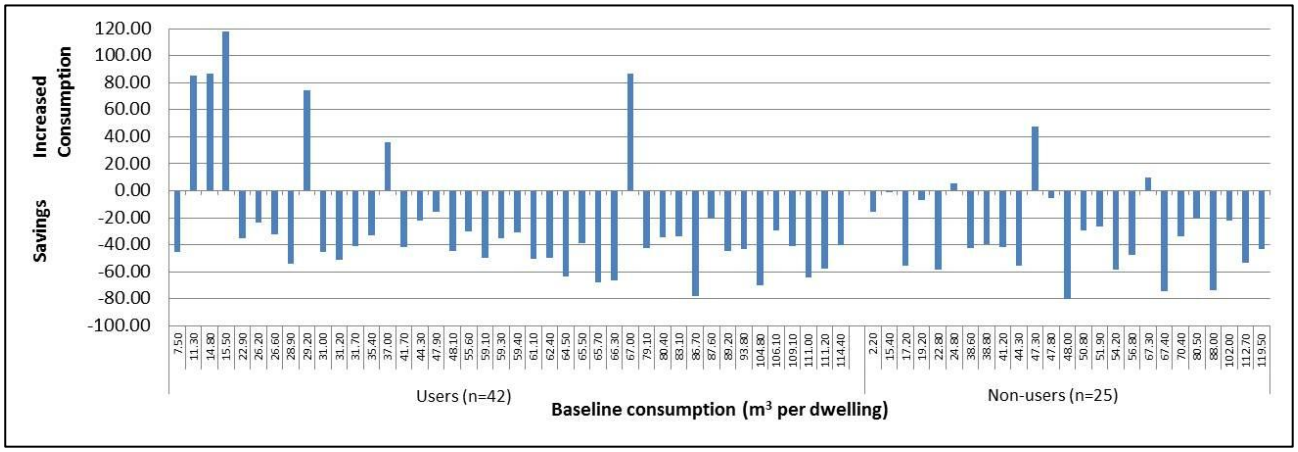


The divergence in the above savings presentation is again due to the different calculation approaches. In the present case, that is especially relevant for the users, where few households with low absolute baseline cold water consumption had a comparably large increase in relative

[74] Analysed by t-test related to the individual savings in both groups

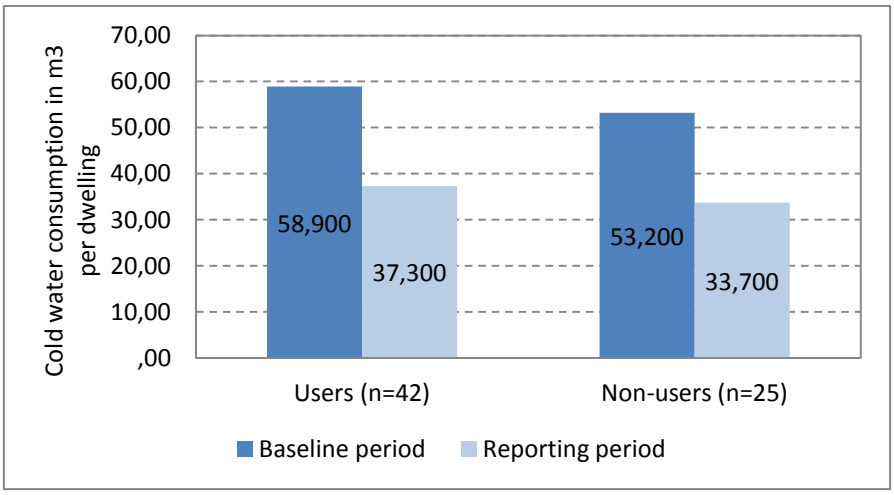
figures which led to a comparably smaller averaged saving result when using calculation model 2. Nevertheless, the measured consumption values seemed to be realistic. That's why these households were not excluded from analysis.

Figure 4.5.9: Savings resp. increased consumption per household (in %) related to the baseline cold water consumption (in m³/dwelling)



As already mentioned above, there was no information available about the number of persons in each dwelling. That's why the following figure includes for each comparison group the average cold water consumption per dwelling only - and not per person which would be a better comparison parameter. As already applicable for hot water, RUAS users also started at much higher cold water consumption level compared to the non-users. But in contrast to hot water, where both groups reduced their consumption similarly, users achieved a comparably higher average cold water reduction: Related to the 10 month observation period the RUAS users reduced their cold water consumption by 21.6 m³, the non-users by 19.5 m³ per dwelling on average.

Figure 4.5.10: Average cold water consumption in m³ per dwelling related to RUAS users and non-users



86% of the RUAS users achieved savings. On average they reduced their cold water consumption by nearly 44% which is a better result compared to the non-users. In contrast, six user households (14%) had an increase of 81% on average, while for a similarly small part of the non-users their cold water consumption increased by 21% only.

These results indicate again the successful monetary stimulus to reduce the cold water consumption in order to save money. That's why also non-users of the RUAS achieved large

consumption reductions. But even the - with the RUAS primarily focussed - target group of high consumers became actual users.

Table 4.5.6: Percentage of dwellings with hot water savings/increased consumption and correspondent average figures related to RUAS users and non-users

	Users	Non-users	Exp. Group in total
Absolute number and percentage of dwellings with savings	36 (86%)	22 (88%)	58 (87%)
Average savings of dwellings with savings	-43.5	-40.2	-42.2
Absolute number and percentage of dwellings with increased consumption	6 (14%)	3 (12%)	9 (13%)
Average increased consumption of dwellings with increased consumption	+81.1	+20.9	+61.0

4.5.3 Results of survey analysis

Results of mid-term survey

Örebro addressed the mid-term survey to one area manager, two IT-technicians, two local housing managers and nine tenants.

The area manager reported that there is generally a very positive feedback related to the fact that tenants can review their own consumption via tenant portal. She received no negative comments from tenants. Especially there were no problems reported on login or user friendliness or further complications. There was one incident of two meters being mixed-up which could be quickly corrected. From the tenants she experienced that the tenant service has influenced their consumption behaviour and they rather take a shower instead of a bath. The brochures provided in the BECA project together with information meetings were helpful and facilitated the job of the area managers. The manager thinks that it will be interesting to see how the system influences consumption in the course of time.

The technical partner Camtech[75] provided and operated the meters (replacing another provider). There have been some problems mentioned in the interview. At the medium stage a minority of tenants (from 10-15% down to 5%) were interested in regularly following their consumption. Improvements of that low level require incentives – e.g. a discount shop voucher or something like that. In addition to that, there is a parallel to waste management expected because it seems to be likely that the rate per unit will be increased from the energy provider related to the expected 20% reduction in order to protect their sales. In the end, the environment will be the primary winner because – of course – the tenant can influence consumption and expenditure. There occur cases in houses of retired people with water consumption measurements of Camtech with people showing extreme patterns of absolutely intending to save money (e.g. rarely flushing the toilet). On the other hand, if the social welfare is paying the rent, the reduction logic cannot work sufficiently.

The tenants, who log in the tenant portal once a week, mentioned problems with missing data of several days – even if these are available on an accumulated basis afterwards. From their point of view the data should be updated daily with additional service information on the availability of new data. The graphics and images are easy to understand. In December-January 2012/2013 it was impossible to access the portal due to technical problems. The respondents are absolutely convinced that it is possible to save energy by means of the services. Information and consumption feedback serve as triggers for energy savings. It is a challenge to stay lower than the break even. The fact that one has to pay for the own consumption will improve awareness and savings. The

[75] This company is not a partner in the BECA project.

respondents suggest to provide more information about consumption data and about the BECA project and to install a Question-Answer Forum (Q&A-Forum).

Data basis and profile of respondents at baseline and final survey

The following table shows the number of respondents of each evaluation group and their participation in the survey stages. In total, 88 out of 176 control group tenants participated in the baseline survey (50%). In the experimental group the response rate was even higher (57%, 133 out of 235 tenants. The participation rates of the final survey were 25% in the experimental group (57 out of 230 tenants) and 29% in the control group (52 out of 182 tenants).

The explanations for that drop-out are as follows: Each survey has been conducted in two steps. First, all tenants received a paper questionnaire via postal letter. Secondly, tenants have been called in order to carry out further telephone interviews. The lower response rates of the final survey partly result from a technical problem that occurred during the data entering of the survey answers in the software tool. That's why all data of the telephone interviews were lost (59 in total). Furthermore, it was difficult to motivate tenants for participation once again because some of them had the impression that they already answered in detail in the baseline survey. However, the remaining responses are sufficient for analyses.

Table 4.5.7: Number of respondents per survey stage

Participation at survey stage	Evaluation Group				Total
	Control Group		Experimental Group (RUAS)		
	Non-users*	Users*	Non-users*	Users*	
Only baseline survey	27	27	61	24	139
Only final survey	8	10	10	7	35
Baseline and final survey	16	18	21	19	74
Total	51	55	92	50	248

* Defined on the basis of measured portal logins.

As mentioned above, tenants of the control group have been not informed on the tenant portal by Örebro Bostäder, but could use it by means of the passwords of the general website of the housing company. As table 4.5.7 shows, many control group tenants noticed the tenant portal and used the opportunity for log in. It cannot be excluded that the remaining control group tenants also became aware of the portal and/or received information about it. That's why the planned control group approach is not useful anymore. Instead of that a comparison of users and non-users will be done. This means that analyses about the impact on ecological awareness and behaviour will be done on the basis of pre-post comparisons and comparisons of users and non-users who participated at both survey stages (37 users and 37 non-users). The users were identified by means of measured portal logins.

The questions related to the tenant portal will be analysed on the basis of active users of the experimental group who participated at least in the final survey. The active users were identified by the question about the use frequency of the tenant portal.

The profiles of non-users and users show no remarkable differences. That means that users and non-users represent very homogenous groups. In both groups the majority of respondents were women. Around 90% of the respondents were born in Sweden. The average age is also rather similar. Users and non-users are well educated – the majority has a university or university of applied science degree. The average household size (mean) is two persons in both groups. The absence of all household members from home at a normal week day seems to be somewhat shorter in the user-groups. However, the socio-demographic characteristics show that no bias has to be assumed in the analysis. Therefore the comparison of users and non-users seem to be a

good solution for assessing the impact of the services.[76] However, both groups can differ with respect to their motivation for saving energy or their interest in ecological topics. This should be considered when interpreting the impact of the services.

Table 4.5.8: Profile of respondents in relation of survey participation

Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		Non-users	Users	Non-users	Users
Sex	Male	19 (35%)	20 (37%)	15 (41%)	13 (36%)
	Female	35 (65%)	34 (63%)	22 (60%)	23 (64%)
Country of birth	Sweden	46 (87%)	47 (87%)	34 (92%9	32 (87%)
	Other	7 (13%)	7 (13%)	3 (8%)	5 (14%)
Age	Mean	53	53	58	55
	Median	54	58	61	58
Level of education	No school leaving qualification	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Primary/secondary school leaving qualification	10 (20%)	9 (17%)	9 (27%)	6 (17%)
	Secondary school leaving qualification	16 (31%)	13 (25%)	8 (24%)	11 (31%)
	University entrance qualification	5 (10%)	8 (15%)	4 (12%)	6 (17%)
	University/university of applied science degree	20 (39%)	22 (42%)	13 (38%)	13 (36%)
Size of household	Median (persons)	2	2	2	2
Absence of all household members at normal week day	0-2 hours	10 (21%)	15 (29%)	8 (25%)	14 (39%)
	3-5 hours	10 (21%)	8 (16%)	8 (25%)	7 (19%)
	6-8 hours	8 (17%)	8 (16%)	4 (13%)	4 (11%)
	More than 8 hours	19 (40%)	20 (39%)	12 (38%)	11 (31%)

RUAS use and motivation of tenants

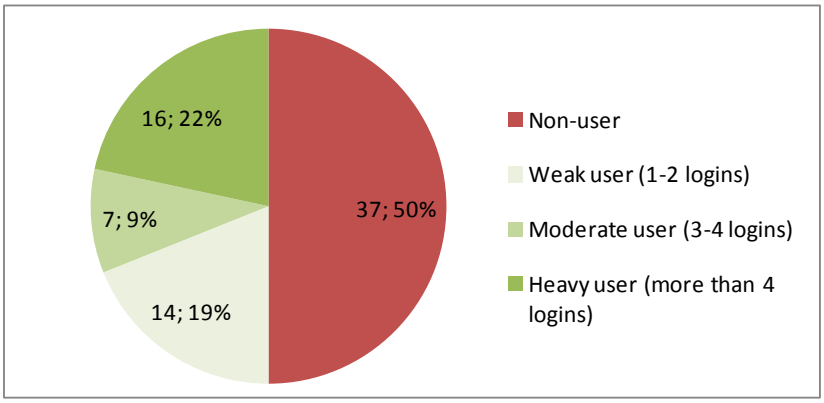
As mentioned above tenants of both evaluation groups were able to log in the tenant portal. The following figure shows the different user groups based on the measured portal logins of all tenants who participated in the baseline and final survey. Half of the tenants belong to the non-users, half

[76] Information about financial support for rent and/or service charges by the municipality is not available in Örebro as it was considered as a very private question that should not be asked in the survey.

logged in the portal at least once. Pre-Post comparisons of ecological behaviour and awareness will be carried out related to these users and non-users.

The portal users were further categorised into three groups: 19% of all respondents belong to the weak users (n=14) logged in once or two times. The moderate users with 3-4 log-ins are the smallest group (19%; n=7). Nearly a quarter of respondents belong to the heavy users with more than four log-ins in the observation period (22%; n=16).

Figure 4.5.11: Portal user groups based on measured logins
(n=74; respondents of baseline and final survey)



Within the different evaluation groups the distribution of the user group is somewhat different – in both groups approx. half of the tenants belong to the non-users (control group: 47%; experimental group: 53%), but more tenants of the experimental group belong to the heavy users (experimental group: 28%; control group: 15%). On the contrary, weak users are more frequent in the control group (experimental group: 15%; control group: 24%). Furthermore, 5% of the tenants in the experimental group belong to the moderate users; in the control group there are 15% belonging to this user group. This means, that tenants who are using the tenant portal, use it more often if they belong to the experimental group than to the control group.

Prior the start of the RUAS, the motivation to save energy consists predominantly in saving money and protecting the environment equally. This is true for non-users (81%) as well as users (76%). At the same time, protecting the environment seems to be slightly more motivating for the users (11% related to the item “protecting the environment more than saving energy”) than for non users (5%) Saving money seems to be more important for the non-users.

After the use of the RUAS, both reasons equally are still considered as most important motives in both groups, but the proportion in the user group decreased to 68%, whereas it was constant in the non-user group (81%). In the user group this change is caused by a shift towards protecting the environment as motivation for saving energy. That proportion slightly increased (16% “protecting environment more than saving money”; 3% “solely protecting environment”). In the non-user group only few persons show a trend towards an ecological motivation.

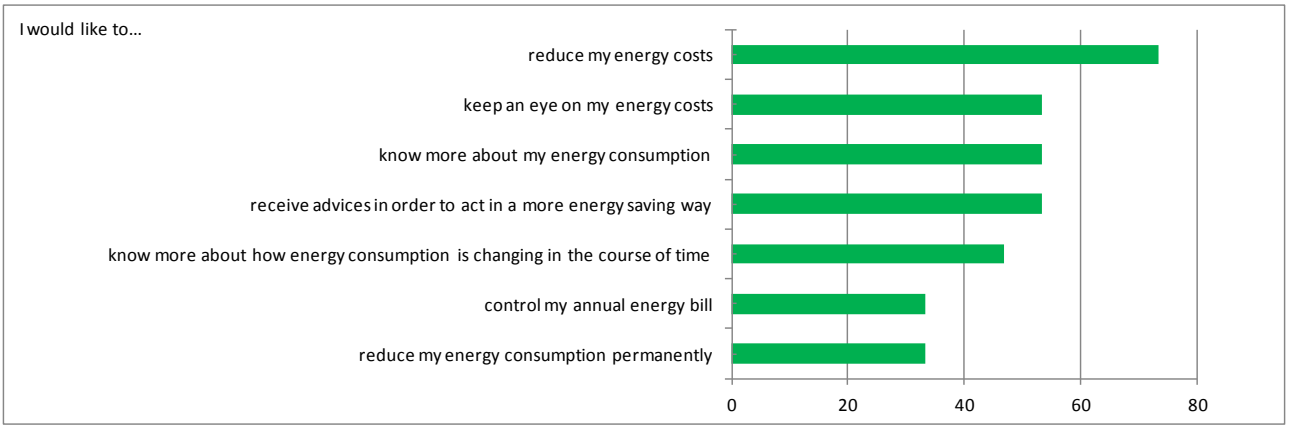
Reasons for using the tenant portal

The tenants of the experimental group were asked about the use frequency of the tenant portal. Tenants, who logged in more often than semi-annually, were considered as active users. This subgroup has been asked about the reasons for using the portal. In the sample of the final survey, 15 out of 42 tenants belong to these active users. 13 tenants logged in at least semi-annually (31%), 14 tenants reported that they have never logged in (33%).

The most important reason for using the tenant portal consists in the reduction of energy costs. Nearly three quarter of the active users strongly agree with this reason (11 out of 15 tenants). To keep an eye on the energy costs, to know more about the energy consumption and to receive advices in order to act in a more energy saving way were motives mentioned from more than half

(eight tenants). This evidences that the tenants would like to learn more about their consumption and about what they can do to reduce it. To see how the energy consumption is changing in the course of time is important for seven tenants. However, the permanent reduction of the energy consumption at home is only seen from one third of the tenants as important reason for using the portal. The same applies to the control of the annual energy bill (five tenants in each case).

Figure 4.5.12: Reasons for using the tenant portal
(n=15; active users; percentages for "strongly agree")



Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

Reasons for not using the tenant portal

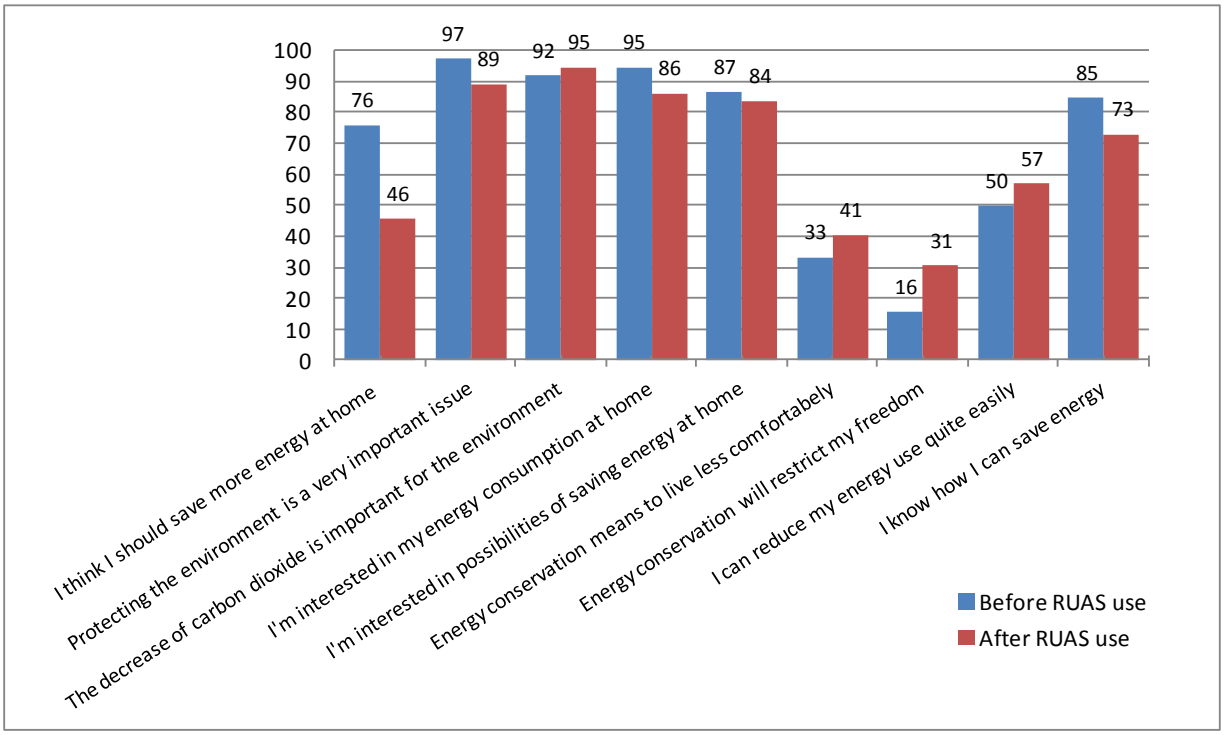
Reasons for not using the tenant portal have been stated by 10-11 tenants. Based on the answer category "I strongly agree", six tenants reasoned that they have already enough knowledge and that's why no further information is needed. Further obstacles are strongly related to the feedback medium. In each case five tenants have no possibility to use the internet or prefer paper information. However, a lack of interest in energy saving issues cannot be seen as important reason for not using the portal (no one strongly agreed; one tenant rather agreed).

Impact on ecological awareness

The following figure shows how the ecological awareness developed with the RUAS use. It becomes obvious that most statements are already at a rather high level before the RUAS use. This is especially true for the general statements about the importance of environment protection and the interest in personal consumption and saving possibilities. For most of the items there is no improvement of the ecological awareness obvious. Increases can be found for the statements "The decrease of carbon dioxide is important for the environment" and "I can reduce my energy use quite easily". Furthermore, the perception that energy conservation means a restriction of comfort and freedom increased.

According to the pilot site manager the negative trend related to the individual energy saving norm ("I think I should save more energy at home") could be caused by the fact that tenants realised the low expenditures for water in Sweden which give no reason for savings. Furthermore many tenants want to protect the environment, but the willingness to change their own behaviour or to take responsibility is rather low.

Figure 4.5.13: Ecological awareness of portal users before and after RUAS use
(n=28-37 due to missing values); percentages for answer categories “strongly agree and rather agree”)



Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don’t know.

Considering the development of the ecological awareness of non-users, it becomes obvious (see figure 4.5.14) that –related to statements with decreasing proportions of the user group – non-users also show negative trends. This means that there are other factors than the RUAS services, which may have an influence. This is confirmed by the pilot site leader who reported that ecological topics were very popular in Sweden not so long ago, but generally the interest and awareness recently decreased.

Hints for a positive RUAS influence can be found in the persuasion that the decrease of carbon dioxide is important for the environment. Related to that, percentages increased in the user group, but decreased in the non-user group.

Figure 4.5.15 shows that the awareness of users is often lower compared to the non-users. An exception is the importance of the decrease of carbon dioxide.

In addition to that, users feel less restricted by energy conservation than non-users, which is also positive. Taking into account the initial situation at baseline stage and the developments in both groups, the agreement with the interest in possibilities of saving energy at home can also be interpreted as promising influence of the RUAS. This is true because the difference between users and non-user diminished during the RUAS use. At baseline stage the percentage difference was -11%-points, now it is -5%-points only.

Realised pre-post and cross-sectional comparisons (mean comparison) reveal no new insights. In general, differences were not statistically significant.

Figure 4.5.14: Changes of ecological awareness of experimental group and control group tenants
(n=28-37 for users and 33-37 for non-users due to missing values[77]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)

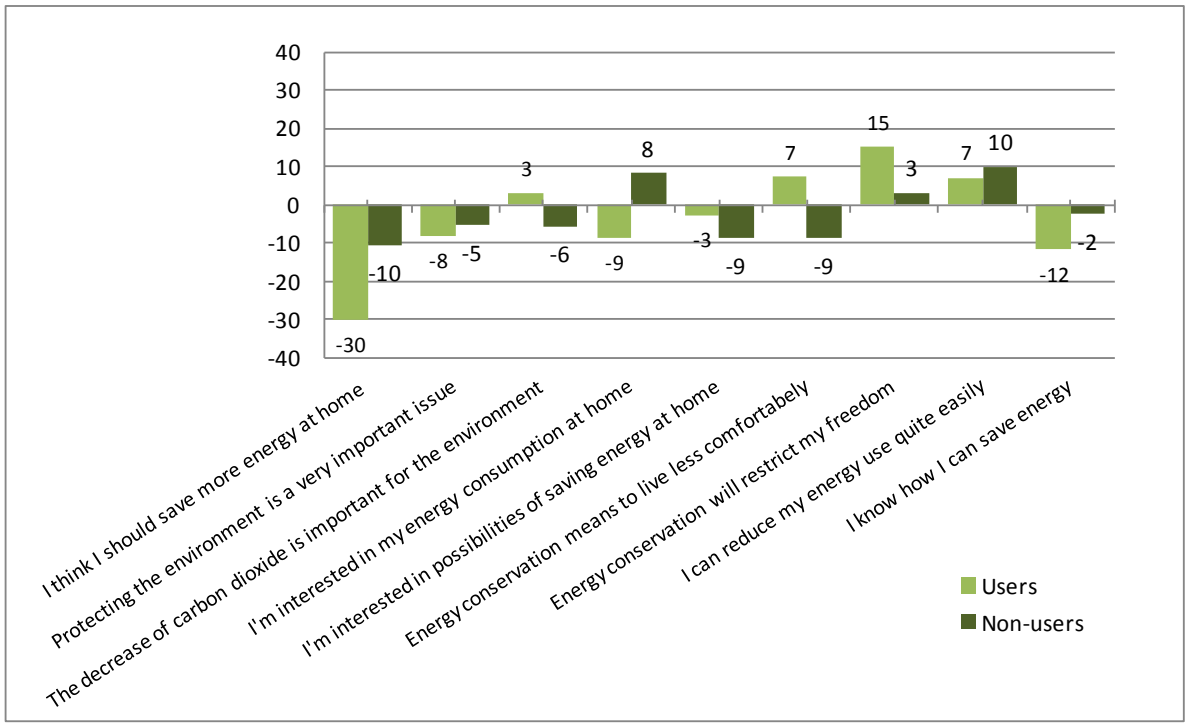
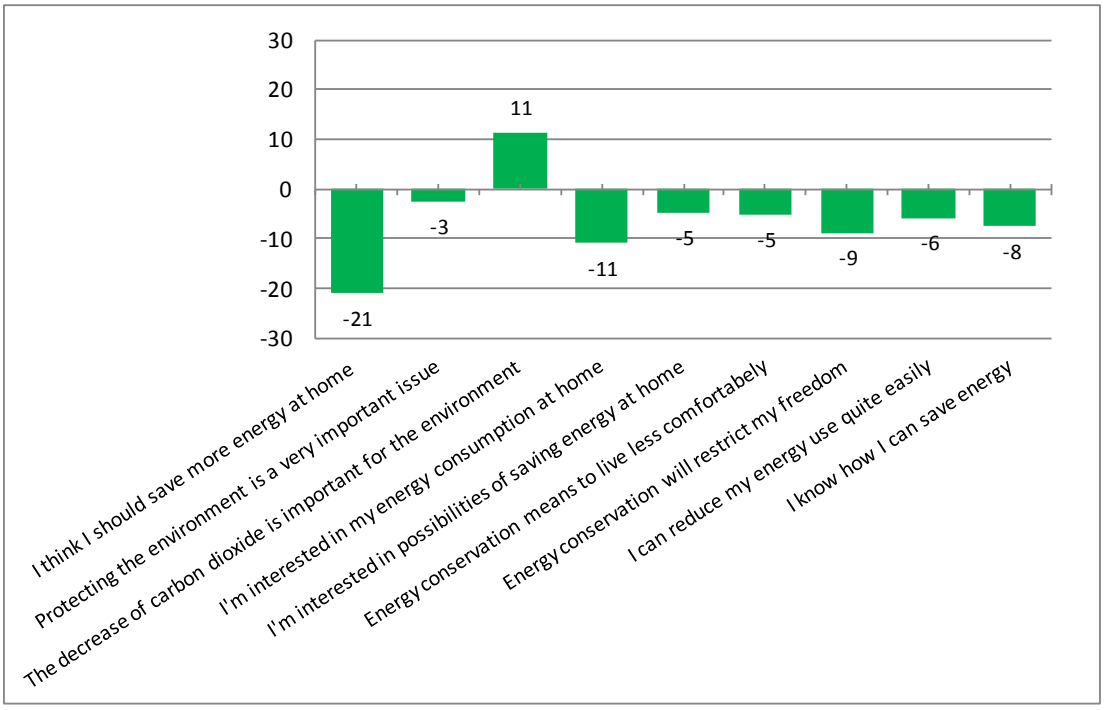


Figure 4.5.15: Differences between users and non-users at final stage
(n=28-37 for users and 33-37 for non-users due to missings[78]; percentage point differences for answer categories “strongly agree and rather agree”)



[77] Answer categories „not applicable” and “don’t know” were coded as missing.

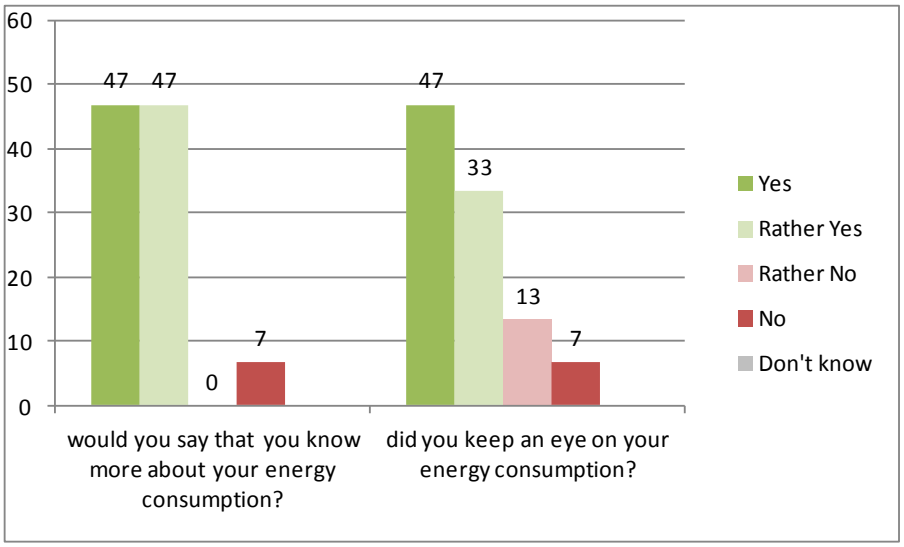
[78] Answer categories „not applicable” and “don’t know” were coded as missing.

The retrospective question about the influence of the tenant portal on knowledge and the relevance of energy saving issues shows positive results. Nearly half of the 15 active users (based on the survey answers) think that they now know more about their energy consumption due to the tenant portal (7 tenants). Further seven tenants are rather convinced to know more about their consumption. In contrary, only one person denies the statements.

In addition to that, again nearly half of the tenants (7 tenants) stated that they kept an eye on their energy consumption. Further five tenants were rather convinced. There are two tenants who stated "rather no" and one tenant who completely denied the statement.

This means, from the tenants' view there is an influence of the tenant portal.

Figure 4.5.16: Knowledge and relevance of energy saving issues resulting from RUAS use
(n=15; percentages)



Question: Thinking of the provided tenant portal…
- would you say that you know more about your energy consumption?
- did you keep an eye on your energy consumption?
Answer categories: "Yes", "Rather yes", "No", "Don*t know".

In summary, pre-post comparisons of users and non-users reveal partly positive influences of the RUAS on ecological awareness. That applies to the general perception of the importance of carbon dioxide reduction and the personal interest in possibilities of saving energy at home. The retrospective view of active users shows very positive results. Nearly all of them know now more about their energy consumption and keep an eye on it.

Impact on ecological behaviour

The ecological behaviour of portal users is very divergent and depends on the different behaviour patterns asked for.

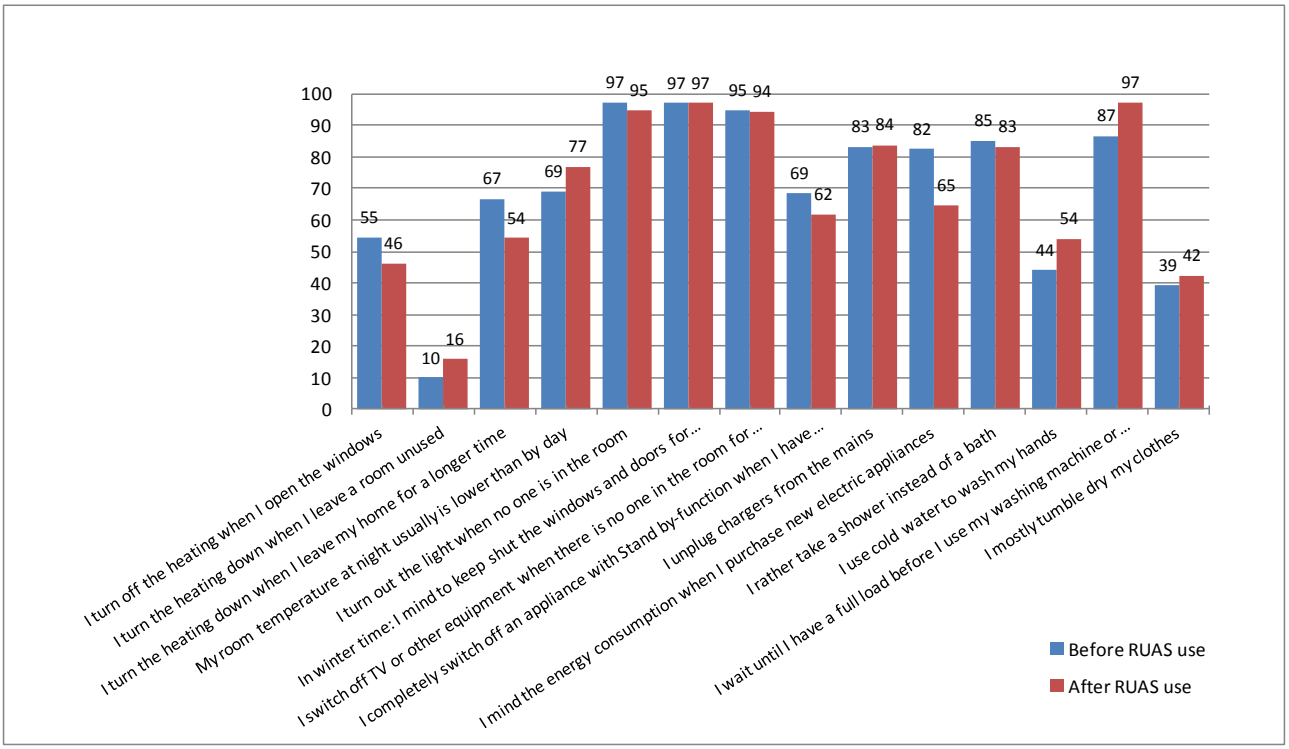
Prior the RUAS use there are high levels of ecological behaviour (nearly 100% agreement) related to two statements addressing electricity consumption ("I turn out light when there is no one in the room"; "I switch off TV or other equipment when there is no one in the room"). The same applies to one heating item ("I mind to keep shut windows and doors in common use room"). This high level of ecological behaviour remained constantly after the RUAS use.

Further statements with rather high levels of ecological behaviour at baseline stage (more than 80% agreement) are related to electricity consumption ("I unplug chargers from the mains"; "I mind

the energy consumption when purchasing new appliances"; "I wait until a full load before I use my dishwasher / washing machine) and water consumption ("I rather take a shower instead of a bath"). Statements with lower agreement levels at the baseline stage are primarily related to heating.

The development with regard to statements with rather high levels and lower levels of ecological behaviour has also no clear pattern.

Figure 4.5.17: Ecological behaviour of portal users before and after the use of RUAS
(n=20-37 due to missings[79]; percentages for answer categories "strongly agree and rather agree")



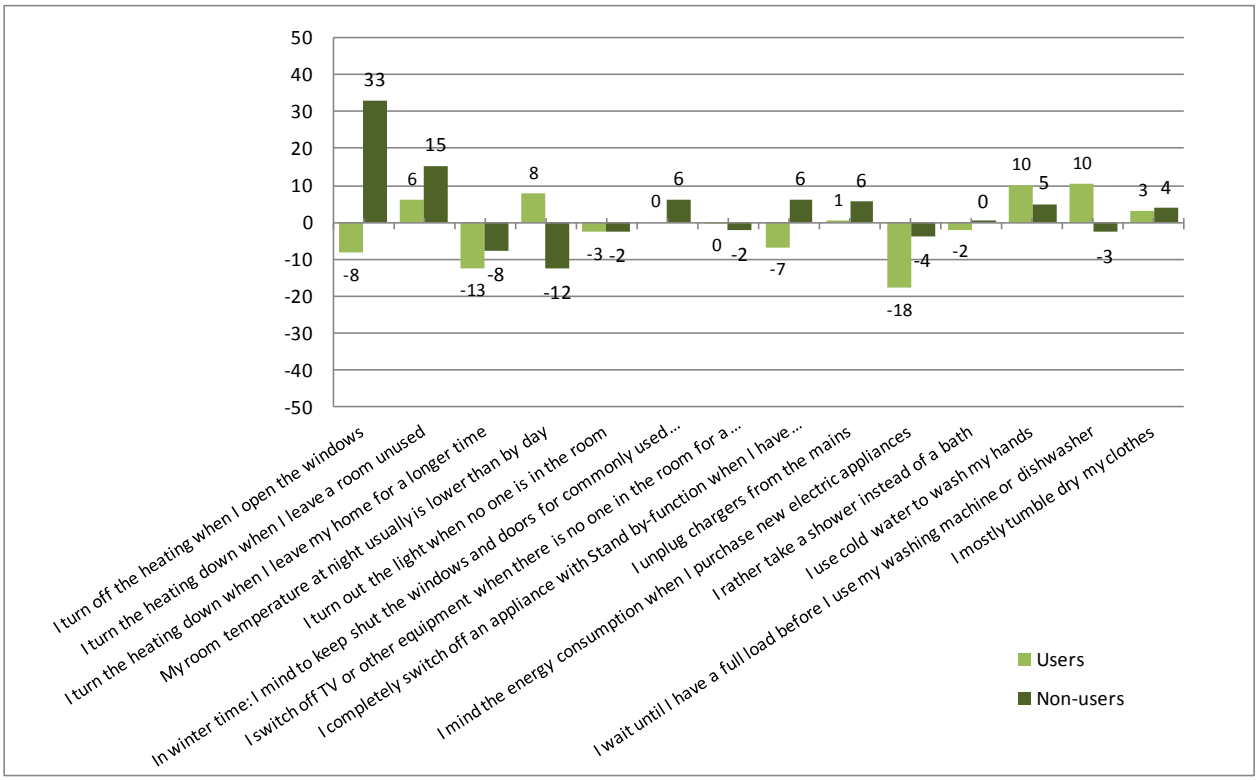
The changes of ecological behaviour of users and non-users show results that suggest influences of the tenant portal. This is true for lowering the room temperatures at night and for waiting until a full load before using the washing machine or dishwasher. Related to both items, portal users show a positive trend whereas non-users reported a negative trend.

In addition to that, the portal users now more often use cold water for hand-washing. As this development is stronger compared to the non-users it can be also interpreted as an influence of the tenant portal. The realisation of mean comparisons doesn't reveal further results as the changes mentioned above are not statistically significant. This means that there might be further influences besides the portal use on the ecological behaviour of the tenants.

Related the other statements no advices for a positive influence of the portal usage can be found. There is either no difference between users and non-users or there is no positive development recognisable. As many statements refer to electricity consumption which was not part of the RUAS in Örebro, this result is not really surprising.

[79] Answer categories „not applicable" and "don't know" were coded as missing.

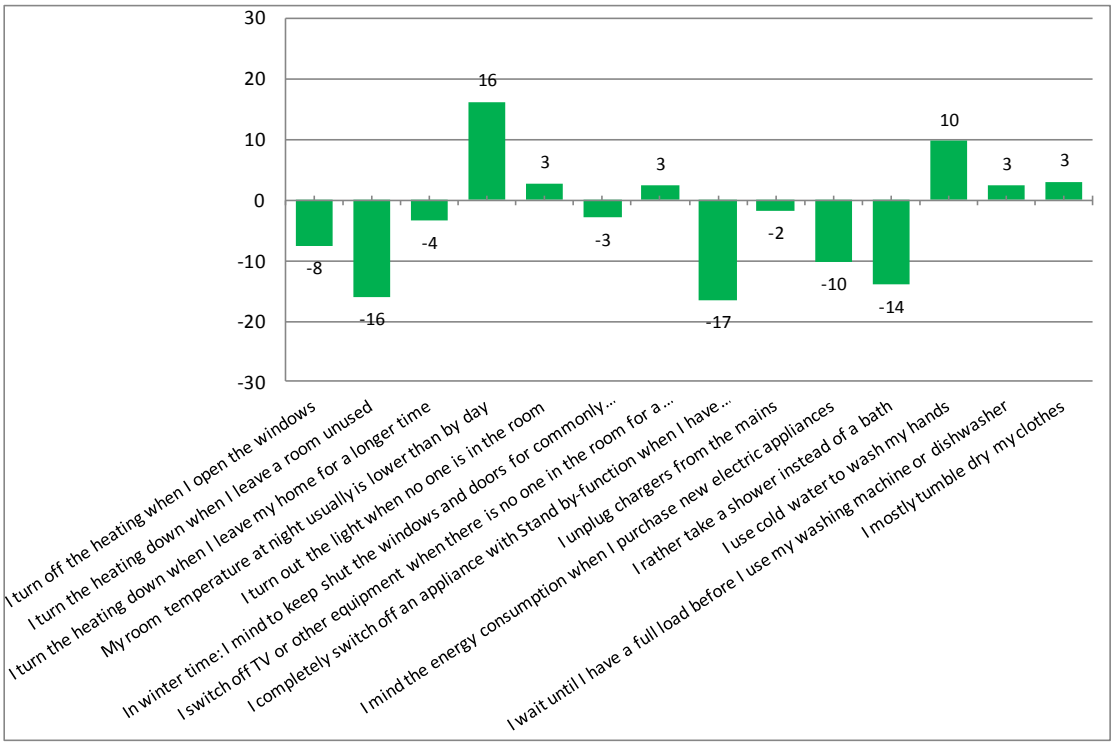
Figure 4.5.18: Changes of ecological behaviour of portal users and non-users
(n=20-37 for users and 33-37 for non-users due to missing values[80]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)



Considering the differences of ecological behaviour of both groups at final stage and taking into account the initial situation at baseline stage, there are some interesting findings: The longitudinal trends for lowering the room temperatures at night and waiting until having a full load before using the dishwasher or washing machine result in the fact that portal users at final stage behave more often in the desired way than non-users. The opposite was true at baseline stage. In addition to that, at final stage more users than non-users use cold water for washing hands and switch off TV or other equipment when nobody is in the room. These differences between user and non-users are bigger than they were at baseline stage. Even though these findings are also not statistically significant (based on mean comparisons) they can be interpreted as positive tendency of the RUAS impact.

[80] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.5.19: Differences between users and non-users at final stage
(n=24-37 for users and 25-37 for non-users due to missings[81]; percentage point differences for answer categories “strongly agree and rather agree”)



Ventilation behaviour

The ventilation behaviour of users and non-users at final stage[82] shows that – if tenants open windows – users and non-users mainly ventilate in the recommended manner by opening windows widely at times or leaving windows ajar at times. In contrast to the portal users, non-users predominantly ventilate living rooms and kitchens by opening windows widely at times.[83]

Asked for the duration of leaving windows ajar, the majority of users (80%) and non-users (69%) reported they do not keep windows ajar over a period of at least one hour a day. Although users more often use tilt ventilation at times than non-users, they more often restrict the duration to less than one hour a day. This means that users as well as non-users behave in a quite ecological manner. As there are no big differences between both groups this seems to be not influenced by the tenant portal.

[81] Answer categories „not applicable” and “don’t know” were coded as missing.

[82] A pre-post comparison was not possible due to a question modification at final stage. The analysis is based on tenants participated at least at the final survey.

[83] The ventilation of “other room” is not included in the analyses due to small sample sizes (users: N=5; Non-users: N=2.

Figure 4.5.20: Ventilation behaviour of portal users in winter time (final stage)
(n=12-50 due to missings[84]; percentage)

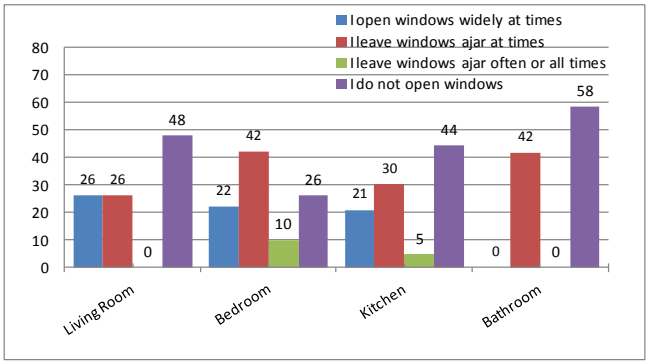
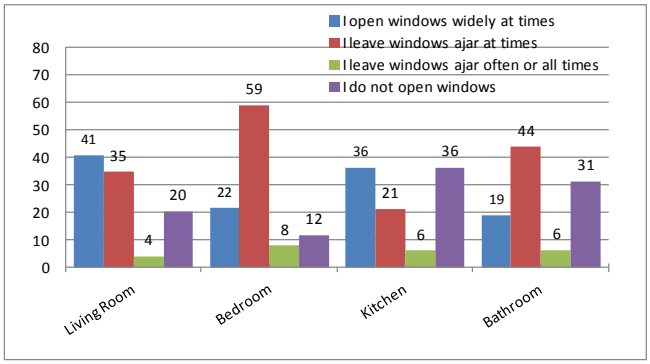


Figure 4.5.21: Ventilation behaviour of non-users in winter time (final stage) (n=16-51 due to missings[85]; percentage)



Retrospective and prospective behaviour

The 15 active portal users[86] have been asked whether the portal usage has influenced their behaviour and whether they intend to save heat energy next winter or not.

The retrospective view shows positive results. Nearly half of the active users are of the opinion that they changed their behaviour as a result of the portal usage (7 out of 15 tenants). Only four tenants denied this statement, further four tenants didn't know. This positive result is also reflected in the behaviour pattern of those active users. Here the number of active users who act in pro-ecological manner increased for nearly all statements.

Considering the prospective view on the tenant's behaviour, the positive picture of the active users is confirmed. Nearly all of them (14 tenants) intend to conserve heat energy next winter, the remaining person denied the statement.

Besides the success already found for the active users, this shows also a positive outlook. It is very likely that those persons will strengthen their efforts and they will do this by means of the tenant portal. So, the influence of the portal might increase at long term.

In summary, the usage of the tenant portal led to an improved ecological behaviour related to several aspects of heating, electricity and water consumption behaviour. These results basing on the comparison of users and non-users can be interpreted as at least partial impacts of the tenant portal. In addition to that, the majority of active users (identified via survey) reported on behavioural changes due to the tenant portal. This positive development is confirmed by the intention of nearly all active users to save heat energy in next winter.

[84] Answer category „not applicable/no window in room" was coded as missing.

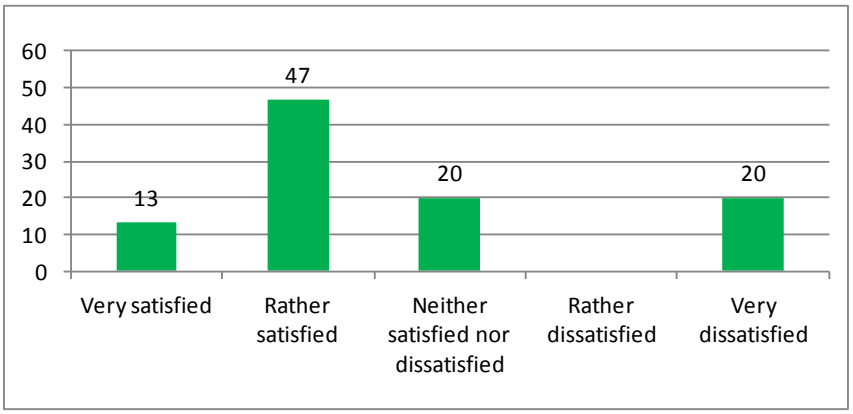
[85] Answer category „not applicable/no window in room" was coded as missing.

[86] identified with the help of the survey question "How often do you log in the tenant portal usually?"

Satisfaction with tenant portal

Figure 4.5.22 shows that the majority of active users are generally satisfied with the tenant portal. 47% (7 from 15 tenants) are rather satisfied and 13% (2 tenants) are very satisfied. However, there is some potential for further improvement as three persons are very dissatisfied and further three persons are neither satisfied nor dissatisfied.

Figure 4.5.22: General satisfaction with tenant portal (n=15; percentage)

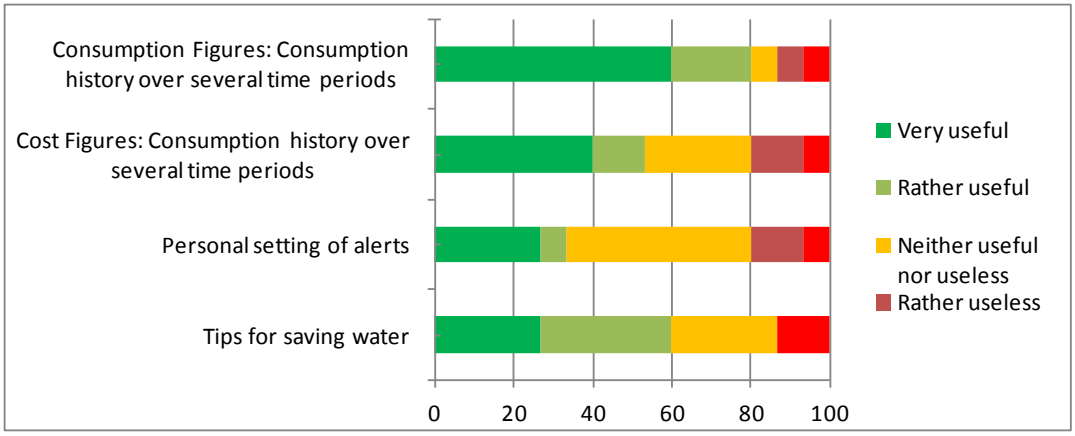


Question: How satisfied are you with the services of the tenant portal in general?

The information presented in the tenant portal is mainly evaluated as useful. The biggest agreement is related to consumption figures providing historical feedback (consumption history). 60% of the active users (9 tenants) consider them as very usefully, further 20% (3 tenants) as rather usefully. To a smaller extent that also applies to cost figures related to the consumption history.

The personal setting of alarms and the energy saving tips for water are assessed as very useful from 4 tenants in each case (27%). More often the tips for saving water are “rather useful”. Related to alert setting there is a comparably high percentage of undecided responses (7 tenants judge it as neither useful nor useless). That could be due to the fact that these tenants do not exactly know how they can make use of it. Furthermore, all information is considered as useless from one up to three persons.

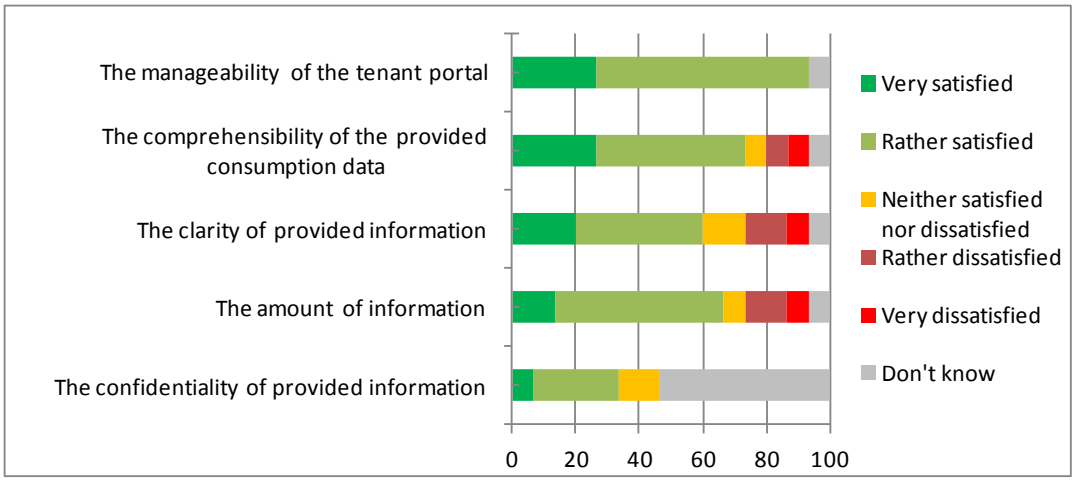
Figure 4.5.23: Usefulness of information presented in the tenant portal (n=15; percentage)



Further aspects – related to the handling of the portal and its information – are mainly satisfying the active users. However, differences with regard to single aspects are obvious. The manageability of the tenant portal is very or rather satisfying (one exception only). The comprehensibility is judged as satisfying from nearly three quarters of the tenants. There are only four tenants with another opinion. The clarity of provided information is assessed from three persons as very satisfying, the amount of information from two tenants. However, more tenants are rather satisfied with this

aspect than with the clarity of information. The confidentiality of information receives the smallest satisfaction score, but this is due to the high amount of persons who didn't know how to judge this aspect.

Figure 4.5.24: Satisfaction with handling of the tenant portal (n=15; percentage)



Despite this rather high satisfaction with the tenant portal, eight tenants mentioned problems occurred during the use of the portal, five of them described them. These problems were related to smaller server problems at the beginning of the services which caused some delays in data updates and slowed the page loading.

Prospective portal use

12 of 15 active users intend to use the tenant portal frequently in future which shows a great success of the RUAS. Three tenants do not intend to do so.

In addition to that, the tenants have been asked about their preferred payment method of water costs. This question was of interest because prior the services flat-rate water costs were included in the rent, but now they are calculated according to the consumption of each household. That's why the tenant portal should make them also familiar with their actual water consumption and costs beside its intention to support the protection of the environment.

In the baseline survey three quarters of the tenants (155 out of 210) preferred to pay water costs according to their consumption. 26% or 55 tenants preferred to have water costs included in the rent. This already high preference for a consumption-dependent billing increased to 88% at final stage (95 out of 108 tenants). This implies that the tenants should be interested in their consumption and therefore also might be interested in the tenant portal.[87]

In summary, the active users are generally satisfied with the tenant portal – even if some problems have been mentioned. The potential of further improvements of the tenant portal seems to be obvious on high level only – in order to change from rather satisfied users to very satisfied ones.

[87] The tenants were not asked if they would pay for a comparable service, because the service shall remain free of charge.

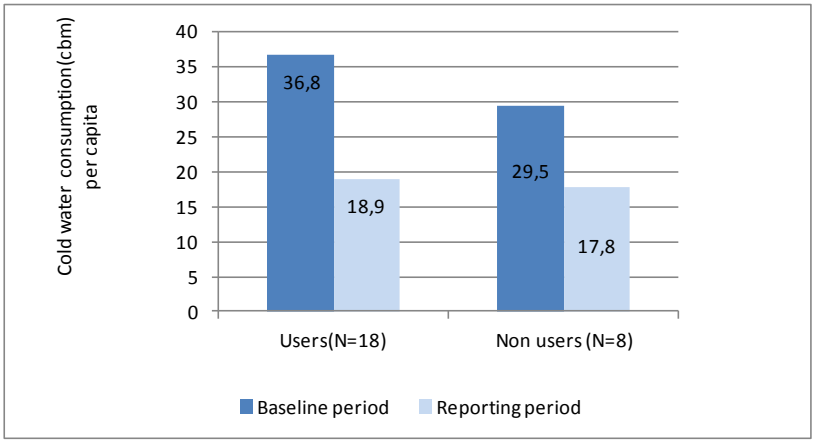
4.5.4 Results of combined analysis

The combined analysis will focus on details about water consumption as in the survey data information about the size of the households is available. Furthermore it will be of interest if the motivation of tenants is related to their savings and if tenants, who think that their ecological awareness has increased and/or their ecological behaviour has improved due to the services, have performed better. Further correlations between behaviour and energy consumption will also be considered with respect to water consumption.

Cold water consumption per capita

The household size is only known for respondents of both baseline and final survey. For this subgroup the average consumption per capita is shown in the following figure. With respect to the cold water consumption per capita it becomes obvious that portal users and non-users consumed much less water in the reporting period than they did in the baseline period. This difference is for users somewhat higher (-17.9 m^3/capita) than for non-users (11.7 m^3/capita). That implies that the new individual consumption billing might have been motivation in both groups, but that the users additionally are beneficiaries of the RUAS. Nevertheless, it has to be pointed out that the average consumption per capita in the baseline period was higher in the user group and the potential for achieving savings therefore was higher than in the non-user group.

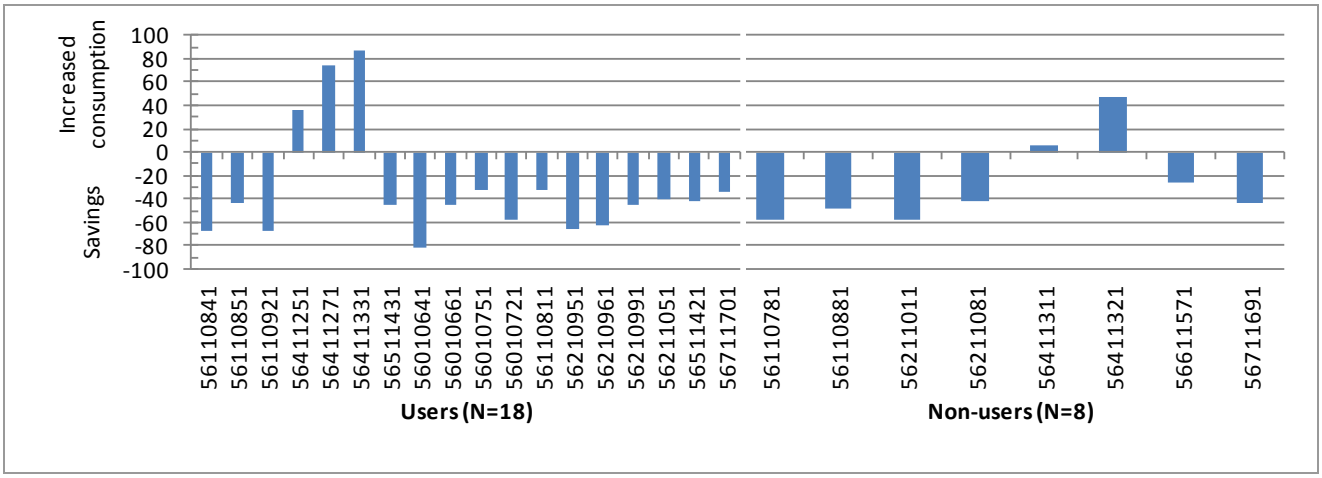
Figure 4.5.25: Average cold water consumption per capita related to user groups



This result is also reflected in the percentage changes. Users achieved savings of 31.3%, non-users of 27.9%. This result might deliver a more appropriate view than the analysis in section 4.5.2 which was based on the average consumption per dwelling and that could not be adjusted per capita as the number of persons in the household is not known for all dwellings. Even if the difference is not statistically significant (based on t-test), it can be concluded that the tenant portal has contributed to the achievement of savings of the user group.

As the following figure shows, nearly all tenants of the user group and the non-user group achieved remarkable savings. However, some tenants of the user group achieved savings of more than 60% whereas non-users achieved savings of 58% at maximum. In both groups there are few tenants with an increased consumption. All those tenants showed a very low consumption already in the baseline period which makes it quite hard to improve even more. Their consumption varies between 9.7 and 18.5 m^3/capita and is much lower than the average consumption of 34.1 m^3/capita.

Figure 4.5.26: Percentage change in cold water consumption (based on consumption/capita) related to user-groups.

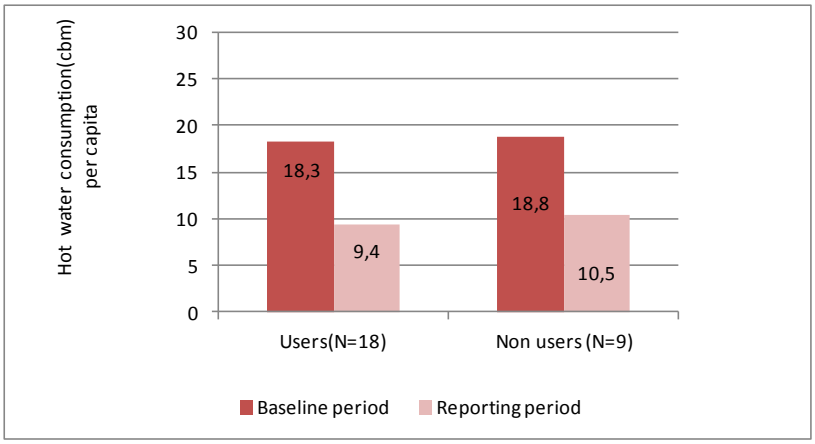


When differentiating the users into weak (1-2 logins), medium (3-4 logins) and heavy users (more than 4 logins) it becomes that weak users saved less cold water (-3.5%) than medium (-53.3%) and heavy users (-47.3%). That's why a quite regular use of the portal contributes to the achievement of more savings. However, as the sample sizes are quite small this result should be treated carefully.

Hot water consumption per capita

With respect to hot water consumption per capita the initial consumptions of users and non-users were quite similar. However, the users show a slightly higher reduction of their consumption (-8.9 m^3/capita) than the non-users (-8.3 m^3/capita).

Figure 4.5.27: Average hot water consumption per capita related to user groups



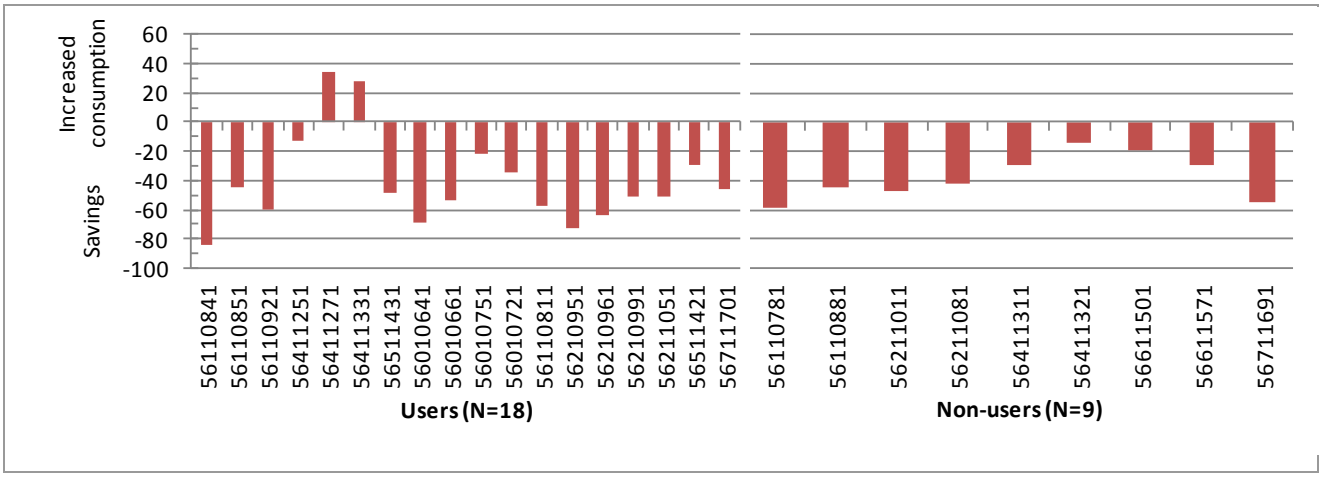
Considering the percentage changes of average hot water consumption per capita, users achieved higher savings (-40.9%) than non-users (-37.7%). As related to cold water this means that the savings of users can be interpreted as partly caused by the tenant portal – even if the differences are not statistically significant (t-test). Again, this result somewhat revises the findings of section 4.5.2 with a dwelling-wise savings calculation which could not be adjusted to the consumption per capita. As the number of persons in a household is especially crucial for the water consumption, the adjusted consumptions per capita are more appropriate even if the results base on a subsample of dwellings only.

When looking on the dwelling--wise percentage changes of users and non-user, there were only two dwellings with increased consumption. Both dwellings belong to the user group and have

below-average baseline consumption. Besides these dwellings, the portal users generally achieved higher savings than the non-users.

The log-in frequency also shows an effect on the savings. Weak portal users with 1-2 log-ins achieved average savings of 26.7%, whereas medium users (3-4 logins) saved -48.5% and heavy users (more than 4 logins) even saved -50.4% of their initial water consumption. This means that with respect to hot water consumption a frequent portal use pays off.

Figure 4.5.28: Percentage change in hot water consumption (based on consumption/capita) related to user-groups.

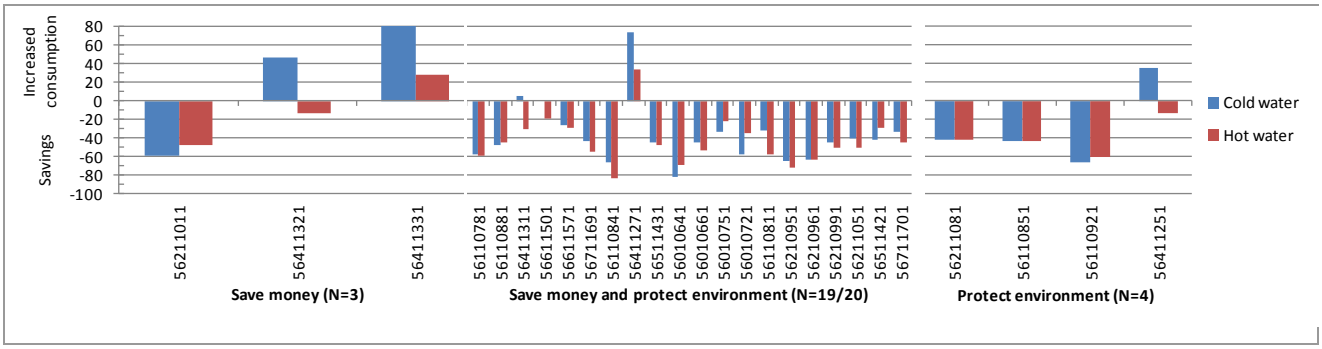


Energy saving motivation and water savings

Due to the new water billing system in Örebro (tenants are paying water according to their consumption now) it was assumed that saving money represents the major driver of all tenants. However, it is known from the survey analysis (see section 4.5.3), that in fact both motives – saving money and protecting the environment – are equally considered as the most important motivation for saving energy. This is true for users and non-users of the tenant portal, but within the user group more tenants mention ecological reasons than within the non-user group.

Now it is of interest, if and how the kind of motivation is related to the achieved savings. Although there are only three tenants who solely feel motivated by saving money and four tenants with solely ecological motivation among the tenants with known consumption data, the findings are interesting.

Figure 4.5.29: Percentage change in water consumption (based on consumption/capita) related to energy saving motivation.



As shown in the above figure, a solely monetary motivation does not lead to the biggest savings. In contrary, tenants who feel motivated by solely ecological reasons have more often saved water.

However, the subgroup of tenants who feel motivated by both reasons achieved the biggest savings of cold and hot water. The only exception in this group is one tenant with very low baseline consumption (9.7 m^3/capita cold water; 8.7 m^3/capita hot water) and therefore limited possibility for further reduction.

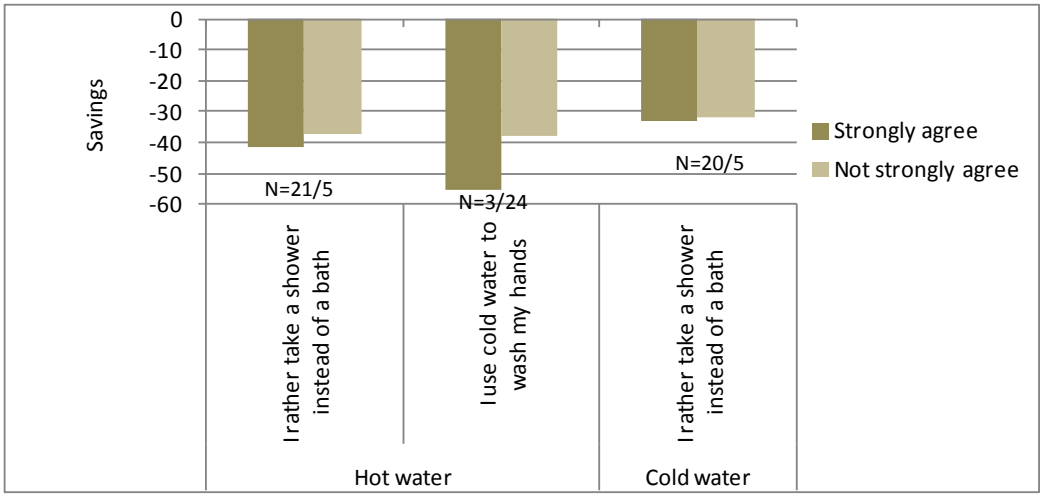
Everyday ecological behaviour and water consumption

With respect to the relation between ecological behaviour and water consumption resp. percentage changes, it is not possible to consider the behavioural changes related to the resource performance because both data are available for very few tenants only. Instead, it is considered if tenants who reported on ecological behaviour in the final survey achieved higher savings than tenants who do not behave in an ecological manner.

As the following figure shows, tenants who strongly agree with the relevant behaviour items ("I rather take a shower instead of a bath"; "I use cold water to wash my hands") achieved slightly higher savings than tenants who do not strongly agree. The strongest influence can be found for using cold water for washing hands on hot water consumption. Tenants who behave ecologically saved 55.6% hot water whereas tenants without ecological behaviour saved 37.8% only.

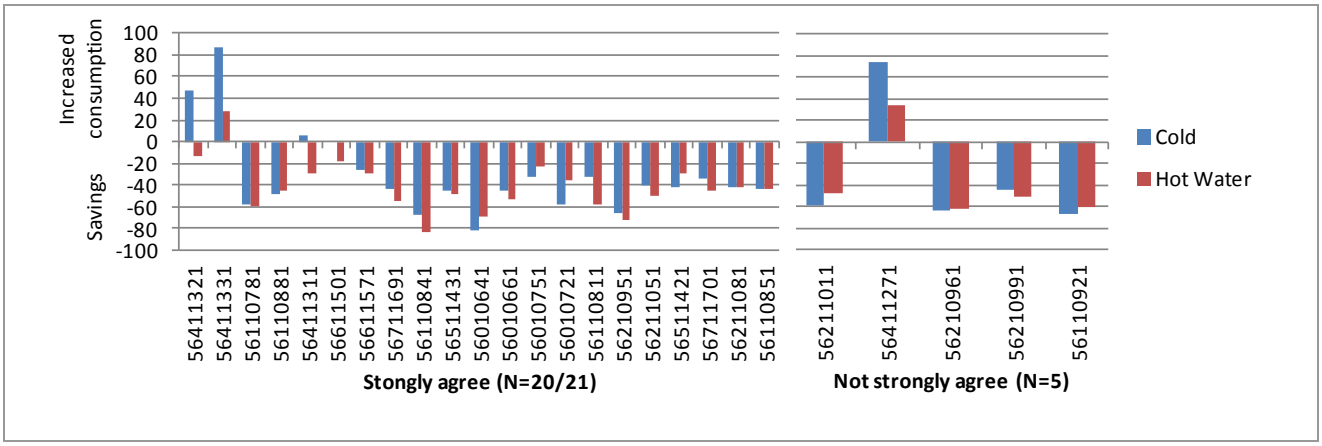
It is also obvious that all subgroups achieved enormous savings independently from their behaviour. This can be again explained with the new water billing system.

Figure 4.5.30: Percentage change in water consumption of respondents with and without ecological behaviour reported in final survey



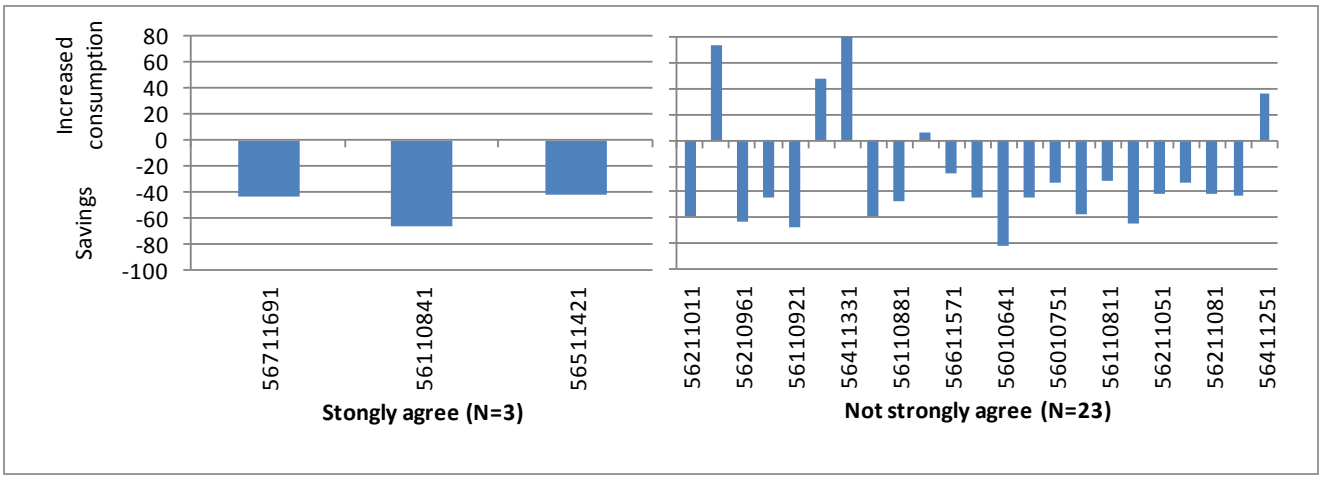
As the sample sizes are very small and average savings might be biased by savings of single tenants, the following figures show the percentage changes per dwelling. With respect to the behaviour item "I rather take a shower instead of a bath" no clear influence of the behaviour on the achieved savings / increased consumption can be observed. Besides few tenants, all remaining achieved savings whereas the savings of tenants with ecological behaviour are not generally higher than of tenants without ecological behaviour.

Figure 4.5.31: Percentage change in water consumption for tenants of with and without ecological behaviour: I rather take a shower instead of a bath



With respect to the behaviour item “I use cold water to wash my hands” and the achieved savings of cold water, there are some hints for an influence of ecological behaviour. All three tenants with self-reported ecological behaviour achieved savings while tenants without ecological behaviour not always did.

Figure 4.5.32: Percentage change in cold water consumption for tenants of with and without ecological behaviour: I use cold water to wash my hands



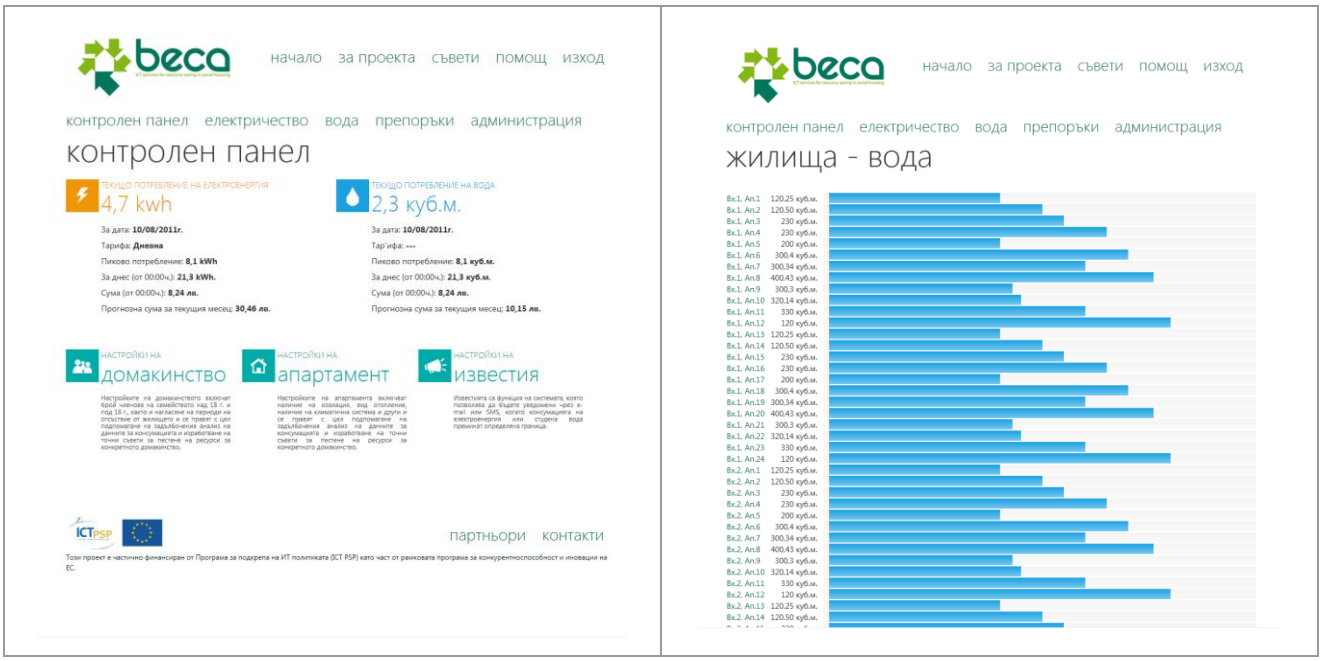
However, the influence of the new billing system generally seems to be of stronger influence than the everyday behaviour of tenants that can hardly contribute to achieve more savings.

4.6 Ruse

4.6.1 Background information

In the pilot site of Ruse RUAS and RMS services were implemented targeting cold water and electricity consumption. The RUAS consists of a tenant web portal providing several features such as consumption data visualisation in combination with comparison parameters as previous periods and average values, target setting and saving tips. Furthermore tenants can interrogate personal alerts in cases when the set targets are overspent. In addition to that, users can personalise their profile by storing their specific absence profile and dwelling characteristics in the database. In addition to that, tenants receive monthly reports with recommendations on resource consumption.

Figure 4.6.1: Screen shots of RUAS tenant portal (left) and RMS professional portal also visible for tenants (right)



In deviation to former plans, an additional RMS was installed using the dwelling-wise available consumption data. It serves as a monitoring instrument focussing on high consumers in order to carry out a sophisticated energy coaching concept addressed to those tenants whose automatic advices (provided by RUAS) did not show the desired effects. Therefore the RMS provides AMEA with alerts based on the periodic consumption information which is also used for carrying out statistical analyses and contacting “eye-catching” households. The threshold for the alerts could be set in comparison to the settings of the control group. Furthermore, at the beginning of the services some of the energy coaching meetings were made with the whole experimental group (all were invited) in order to introduce them into the topic of saving energy. The further communication of energy coaches was mainly with heavy consumers. Within the energy coaching tenants get individual electricity and water saving tips and further information from best practices of other BECA partners and further projects in order to help them to improve their resource consumption behaviour and to achieve peak demand reduction[88].

[88] The topic “peak demand reduction” is currently part of the information provided in energy coaching and one of the (future) aims of the RMS. Further developments are ongoing. Thus, peak demand reduction was not part of the consumption data analysis.

In addition to that, several meetings were conducted with tenants to get their impression of the general work of the system and to recognize if they have any problems with the web-portal, or the saving of energy and water at all.

RUAS and RMS started operation in October 2012 after an 11-month baseline consumption measurement (Dec 2011 – Oct 2012). In order to allow consistent pre-post comparisons the reporting period covers an equal time period (Dec 2012 – Oct 2013). In addition to that, the RUSE pilot evaluation followed a control group approach.

In total, 120 dwellings in two buildings were part of the BECA project, but five dwellings are owner-used residential property. In these cases no consumption data were available. Therefore, the experimental group consists of 45 dwellings and the control group of 70 dwellings.

Table 4.6.1: Basic population of dwellings belonging to experimental and control group

Group Status	Building 50	Building 121	Total
Experimental group RUAS	x		
Control group RUAS		x	
Experimental group RMS	(x)[89]		
Dwellings with measurements	45*	70**	115

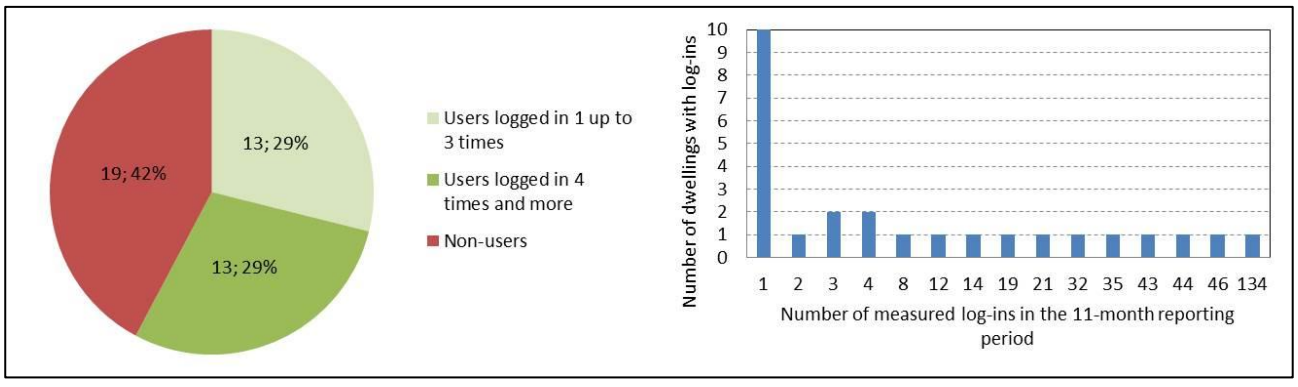
* This figure does not include 3 dwellings of owner-used residential property.

** This figure does not include 2 dwellings of owner-used residential property.

Tenant recruitment in Ruse was focused on face-to-face interaction with the experimental tenants. Strong emphasis was put on the probably monetary impact of the portal use because cost saving is a strong motivation for the people living there. The tenant approach started with the distribution of information letters followed by several tenant meetings. By using the exchange in tenant events, mailing lists were generated in order to send further information (newsletters, articles, etc.) within the project duration. Additionally, workshops for explaining the services were organised (for further details see D.5.2).

Tenants of the experimental group who were interested in the RUAS and that's why logged in the web portal were counted as users. Those who didn't show interest were counted as non-users. The analysis of the measured portal log-ins showed that more than half of the pilot tenants (58%) became users of the portal. One half of them made use of the portal at least quarterly. The median is 3.5 times in 11 month.

Figure 4.6.2: User groups and measured log-ins of RUAS users



[89] As explained in the text, RMS was addressed to high consumers in order to offer in-depth energy coaching.

4.6.2 Results of consumption analysis

In Ruse the consumption measurements were related to cold water and electricity used for space and water heating as well as household appliances and lightning, in some cases also for air condition[90]. The consumption data were available for analysis dwelling-wise and on a monthly basis.

Table 4.6.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Electricity	kWh	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. In the case of electricity 36% of the dwellings had to be excluded from the analysis due to missing data. In the case of cold water 47% of the basic population dropped out. That means: 61 dwellings (water) resp. 73 dwellings (electricity) remained in the analysis sample (see table below).

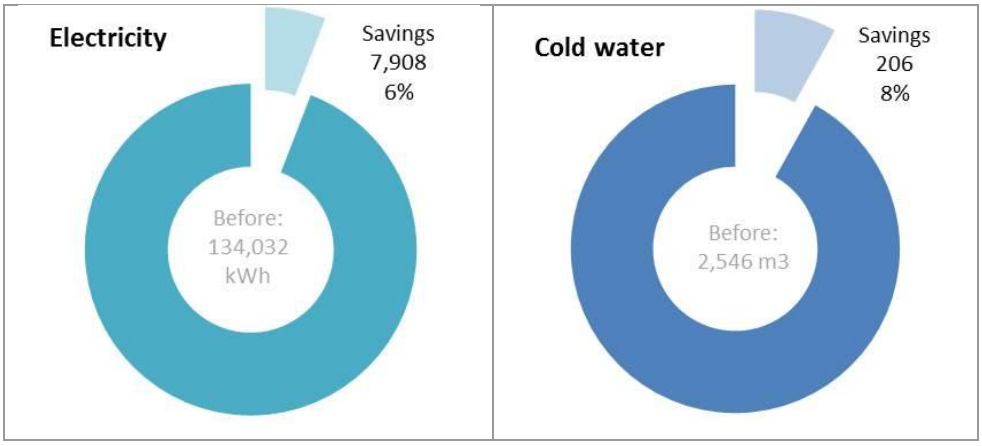
Table 4.6.3: Overview of the number of buildings and dwellings involved in the Ruse pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (number and % of excluded dwellings)
Ruse	2	115	Electricity: 73 (exp. 32+contr. 41) Cold water: 61 (26+35)	Electricity: 42 (36%) Cold water: 54 (47%)

Global results

The calculation of the global savings led to the results shown in the following figure. The tenants of the experimental group saved in total nearly 8 thousand kWh electricity (n=32) and 206 m^3 water.

Figure 4.6.3: Overview of global results of the experimental group in Ruse



Compared to the target setting of 10% savings the achieved results can be assessed as a promising success even if the goal is not fully met today. The detailed analysis below will show,

[90] The separation of heat energy consumption could not be realised due to the availability of dwelling-wise electricity meters only. According to the pilot site leader the information reported in D.7.1 about the dwellingwise measurement of heat energy was wrong.

that actual RUAS users (n=17) achieved even higher electricity savings of 8%. That does not apply for the RUAS users (n=16) in the case of cold water (savings of 6.2%).

The following table gives an overview of the CO_2 and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

Table 4.6.4: Overview of global CO_2- and cost savings of the experimental group in Ruse

Energy / resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Electricity	0.819 kg CO_2/kWh	6,477	daytime: 0.09878 €/kWh night: 0.0604 €/kWh	629*
Cold water	n/a	n/a	1.14 €/kWh	235
Total		**6,477**		**864**

* calculated with the average of daytime and night tariff (0.07959 €/kWh)

Electricity

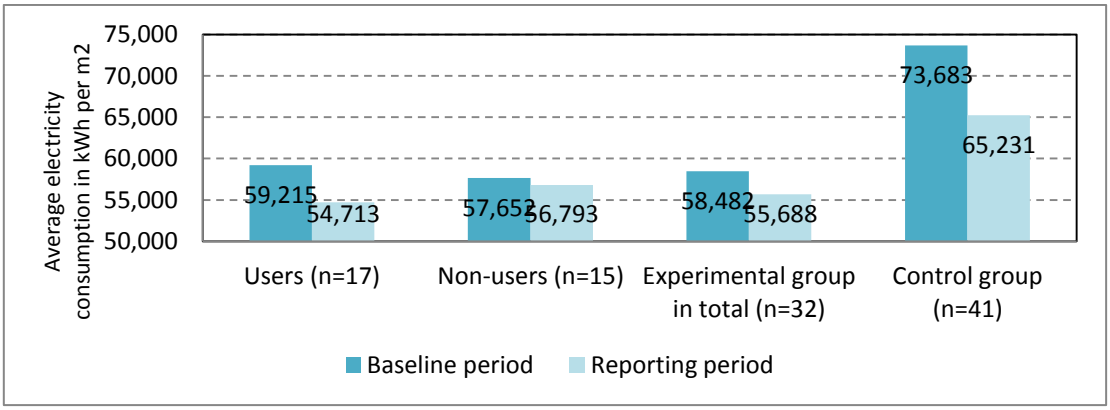
As the following table shows, the composition of the experimental group and the control group is partly different. Especially the dwellings of the actual RUAS users are on average larger than in the other comparison groups.

Table 4.6.5: Dwelling characteristics of all comparison groups

	Experimental group			Control group
	Users	Non-users	Total	
Average net dwelling area (mean value, in m^2)	76.0	64.5	70.6	69.7
Average net dwelling area (median, in m^2)	76.0	69.0	75.5	73.0
Minimum net dwelling area (in m^2)	47.0	46.0	46.0	46.0
Maximum net dwelling area (in m^2)	101.0	98.0	101.0	98.0

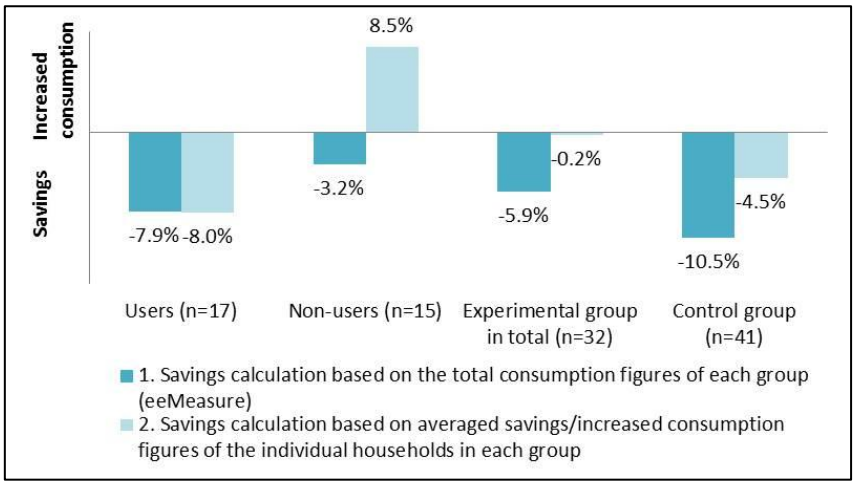
That probably implies that there live bigger households than in the group of RUAS non-users (the household sizes were not available). That corresponds with the following figure showing that RUAS users had a higher average baseline consumption compared to the non-users.

Figure 4.6.4: Average electricity consumption in kWh/m^2 in baseline and reporting period related to all comparison groups



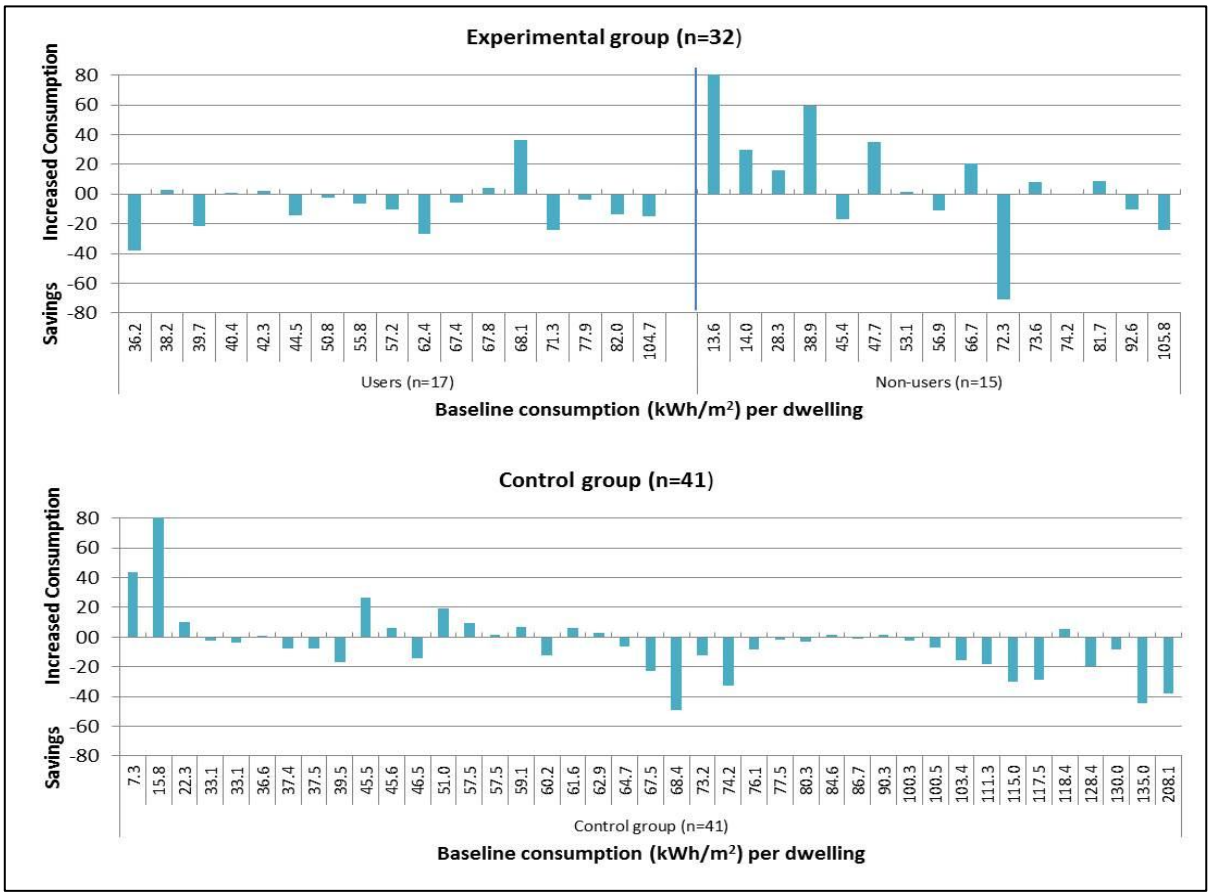
As learnt above, the service in Ruse was especially addressed to high consumers. Bigger households normally have (at least slightly) higher electricity consumption. Thus, their motivation to save money could be one of the reasons why they followed the invitation to become users of the offered RUAS. The positive impact of the RUAS use becomes obvious in the following figure. Users achieved significantly higher savings than non-users.

Figure 4.6.5: Percentage change in electricity consumption related to all comparison groups



The comparably high baseline electricity consumption of the control group led – presumably for the same reasons – to high saving results too. That becomes obvious when looking on the following diagram: Even the high consumers reduced their consumption within the reporting period.

Figure 4.6.6: Savings resp. increased consumption per household (in %) related to the baseline electricity consumption (in kWh/m², each sorted in ascending order from left to right)



In addition to that, that figure provides again the explanation for the divergence of the different approaches for calculating the savings which is in the present case especially relevant for the group of RUAS non-users. A few households with small baseline consumption figures turned their consumption into normal. That led to comparably high relative figures. According to this, these households carry different weight in each calculation model.

The following table shows, that most of the RUAS users (71%) achieved savings. That percentage is significantly smaller in the remaining comparison groups.

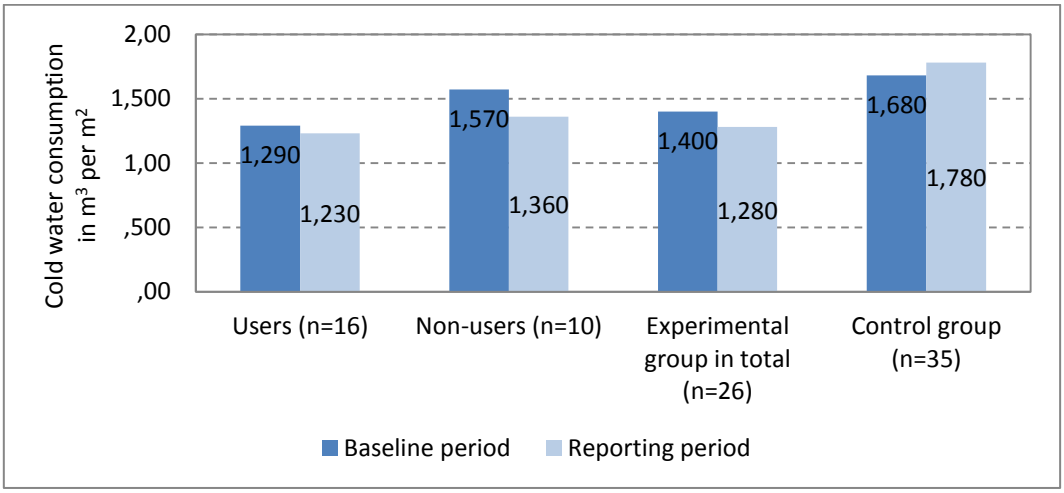
Table 4.6.6: Percentage of dwellings with electricity savings/increased consumption and correspondent average figures related to all comparison groups

	Experimental group			Control group
	Users	Non-users	Total	
Absolute number and percentage of dwellings with savings	12 (71%)	6 (40%)	18 (56%)	26 (63%)
Average savings of dwellings with savings	-15.1	-22.2	-17.4	-16.0
Absolute number and percentage of dwellings with increased consumption	5 (29%)	9 (60%)	14 (44%)	15 (37%)
Average increased consumption of dwellings with increased consumption	+9.2	+29.0	+21.9	+15.4

Cold water

In contrast to the comparably high average baseline electricity consumption, in the case of cold water the RUAS users had comparably low average baseline consumption.

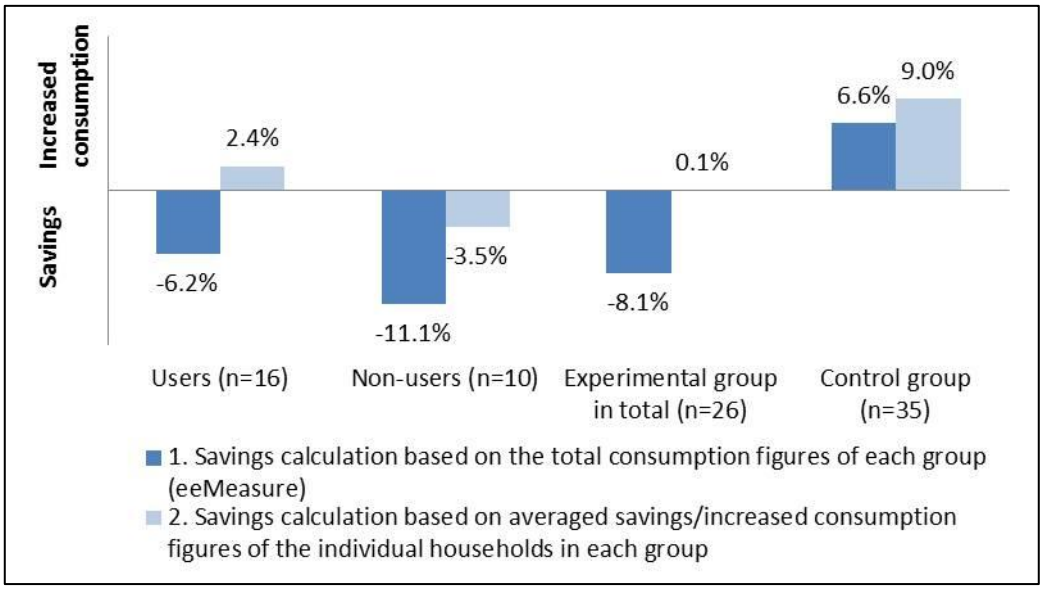
Figure 4.6.7: Average cold water consumption in m^3 per m^2 in baseline and reporting period related to all comparison groups



That is most likely the reason that they achieved lower saving results than the non-users with comparably higher average baseline consumption – due to the fact that their possibility to save even more cold water is limited.

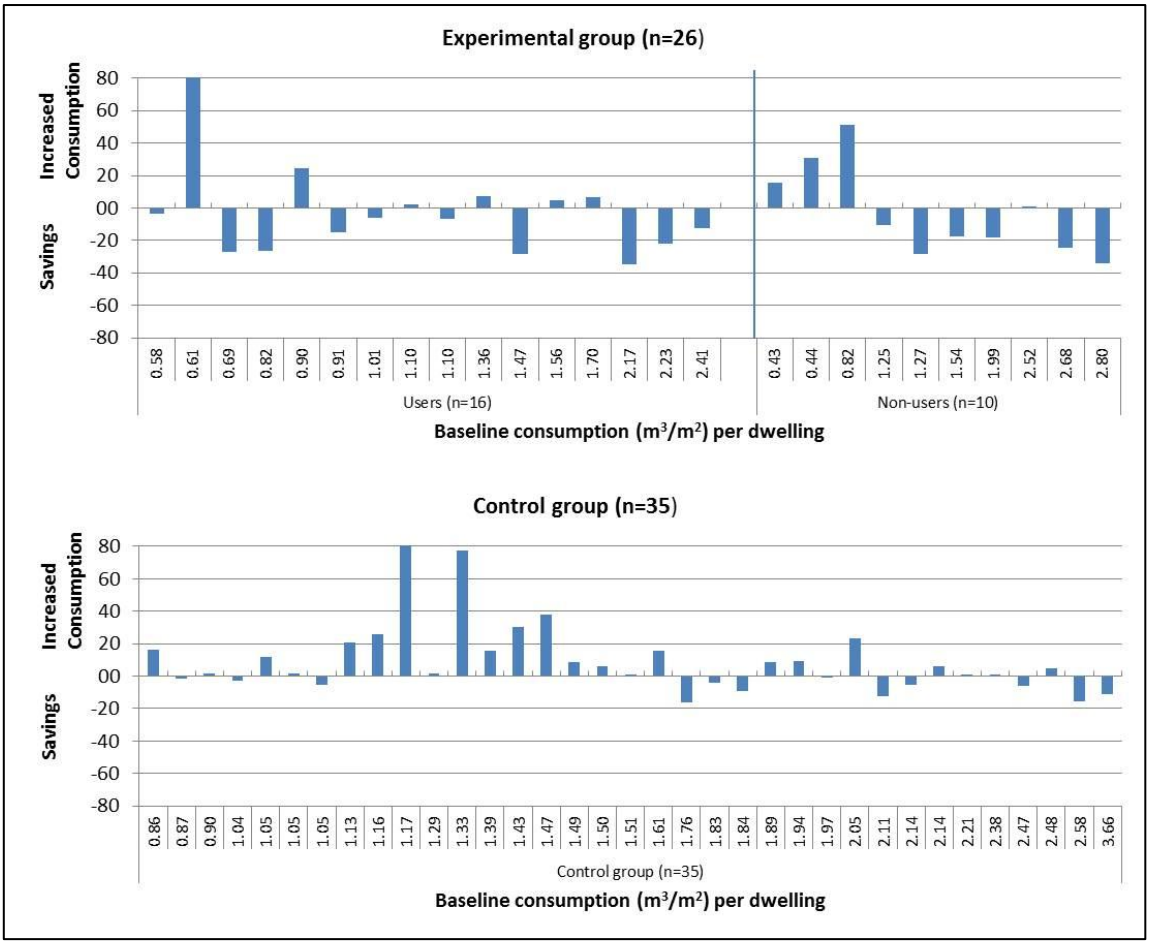
Independently from the used saving calculation approach in each case the experimental group achieved better saving results than the control group with its consumption increase.

Figure 4.6.8: Percentage change in electricity consumption related to all comparison groups



The above divergent calculation results are again due that mathematical issue that a few households with low – but realistic – absolute baseline figures had comparably high relative increases when turning their consumption into normal (see following figure).

Figure 4.6.9: Savings resp. increased consumption per household (in %) related to the baseline electricity consumption (in m^3/m^2, each sorted in ascending order from left to right)



As the following table shows in total 62% of the experimental group achieved significant savings. In the control group that percentage was one third only.

Table 4.6.7:: Percentage of dwellings with cold water savings/increased consumption and correspondent average figures related to all comparison groups

	Experimental group			Control group
	Users	Non-users	Total	
Absolute number and percentage of dwellings with savings	10 (62%)	6 (60%)	16 (62%)	12 (34%)
Average savings of dwellings with savings	-18.2	-22.3	-19.7	-7.6
Absolute number and percentage of dwellings with increased consumption	6 (38%)	4 (40%)	10 (38%)	23 (66%)
Average increased consumption of dwellings with increased consumption	+36.6	+24.6	+31.8	+17.7

4.6.3 Results of survey analysis

Results of mid-term survey

The mid-term survey in Ruse was conducted with 12 tenants in April 2013. In general the results show that these tenants made good experiences.

All 12 tenants did not have any problems with registering and login into the tenant portal. The handling with the portal is easy, without problems, successful and perfect. For all interviewed tenants the graphics and images are easy to understand.

Ten tenants are perfectly satisfied with portal (I know currently nothing I could suggest, the portal is good as it is, no improvements necessary at the moment, I have no suggestions). Only two tenants made suggestions for improvement:

- The portal should have more energy saving tips and should give more advice
- More detailed information – for example hourly energy consumption data

All 12 interviewed tenants learned from the information provided by the portal – about their energy consumption behaviour, about days with especially high energy consumption and about months with high or low consumption. Portal usage problems did not occur. The tenants assess the portal as successful (9 votes), informative (7 votes) and helpful (3 votes)

The tenants regularly log in the tenant portal – with a range from 1-2 times per month up to every day log-ins. The not interviewed household members also know the tenant portal and some of them also use it. Eleven respondents mean that the portal helps tenants to understand their monthly energy and water consumption bill. Eight of them are convinced that portal can help to save energy. Except of one tenant the households already tested the energy saving tips.

Data basis and profile of respondents at baseline and final survey

Table 4.6.8 shows the number of respondents per survey stage. It becomes obvious that pre-post comparisons can be made on the basis of 61 tenants in the control group and 20 tenants in the experimental group. The analyses related to questions about the tenant portal are based on respondents participated at least in the final survey (n=24), but will be restricted to the active portal users.

In general the response rates are very satisfactory for both survey stages. At the baseline stage the response rate is 80% in the experimental group (36 out of 45 tenants) and 87% in the control

group (65 out of 75 tenants). In the final survey participated 53% of the experimental group tenants (24 out of 45) and 83% of the control group (62 out of 75 tenants).

The survey field work was organised in two steps: First, the tenants received the questionnaire as postal paper version with the request to answer the questions and send it back within three weeks. Secondly, tenants who did not send back the questionnaire were contacted again and further personal interviews were made.

However, the number of tenants participated at both panel stages is rather low in the experimental group.

Table 4.6.8: Number of respondents per survey stage

Participation at survey stage	Evaluation Group		Total
	Control Group	Experimental Group (RUAS)	
Only baseline survey	4	12	16
Only final survey	1	4	5
baseline and final survey	61	20	81
Total	66	36	102

The profile of experimental and control group is quite similar. Notable differences are only related to the sex of the respondents: In the control groups (at least final participation; baseline and final participation) there are more female respondents than male ones, whereas that relation is balanced in the experimental groups. In addition to that, the absence of all household members at a normal weekday is slightly shorter in the experimental groups. The age structure is quite similar – even if tenants of the experimental group appear to be a little bit older. The level of education shows rather high levels for both groups. The majority of tenants achieved a secondary leaving qualification, followed by tenants with a university or college science degree. The average household size is 3 persons in both groups (median). Nearly all tenants do not receive financial support for rent of services charges.

Table 4.6.9:: Profile of respondents in relation of survey participation

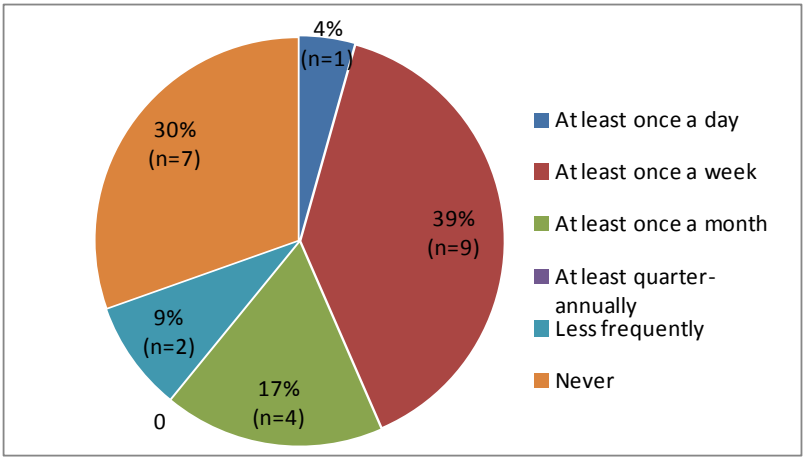
Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
Sex	Male	19 (31%)	12 (50%)	18 (30%)	10 (50%)
	Female	43 (69%)	12 (50%)	42 (70%)	10 (50%)
Country of birth	Bulgaria	61 (98%)	24 (100%)	58 (98%)	20 (100%)
	Other	1 (2%)	0 (0%)	1 (2%)	0 (0%)
Age	Mean	44	45	44	47
	Median	42	40	42	46
Level of	Primary/secondary school leaving qualification	3 (5%)	0 (0%)	3 (5%)	0 (0%)

Characteristics (based on answers at the final survey)		Final		Baseline and Final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
education	Secondary school leaving qualification	38 (62%)	17 (71%)	37 (62%)	14 (70%)
	University / College Science degree	20 (33%)	7 (29%)	20 (33%)	6 (30%)
Size of household	Median (persons)	3	3	3	3
Absence of all household members at normal week day	0-2 hours	6 (10%)	4 (17%)	6 (7%)	4 (21%)
	3-5 hours	19 (31%)	4 (17%)	19 (31%)	4 (21%)
	6-8 hours	15 (24%)	7 (30%)	14 (23%)	6 (32%)
	More than 8 hours	22 (36%)	8 (35%)	22 (36%)	5 (26%)
Rent or service Charges paid by municipality	No	60 (97%)	24 (100%)	59 (97%)	20 (100%)
Rent		2 (3%)	0 (0%)	2 (3%)	0 (0%)

RUAS use and motivation of tenants

As expected, almost all tenants of the experimental group who participated in the final survey heard already about the tenant portal. Only one person negated. This person might be not available during the tenant recruitment, was not reading the information letter or just didn't remember the offer at the moment the question was asked.

Figure 4.6.10: Frequency of portal use
(n=23; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

As the above figure shows, the majority of tenants use the tenant portal at least once a week (39%), followed by 17% tenants who use the portal once a month and one person with daily log-

ins. However, it becomes obvious that seven tenants did not and two persons logged in less frequently than quarter-annually. In total, there are 14 active users representing 61% of the respondents. Therefore questions about the tenant portal will base on those 14 active users.

The social structure of these 14 active portal users shows that male tenants seem to be more likely using the portal. 57% of the active users are men and 43 are women – whereas there is an equal sex ratio in the experimental group including all tenants. In addition to that, the active users are between 27 and 63 years old. The active users are on average 38 years old (median) and non-active users 48 years. This means that the tenant portal seems to be more attractive for younger people. Active users and non active users mainly live with two further persons in a household.

Before starting the RUAS services, the motivation to save energy consists predominantly in saving money and protecting the environment equally. This is true for the experimental group (63%) as well as the control group (61%). The second most motivation in both groups is solely to save money (23% in control group; 21% in experimental group). The remaining tenants stated that saving money is a better motivation than protecting the environment.

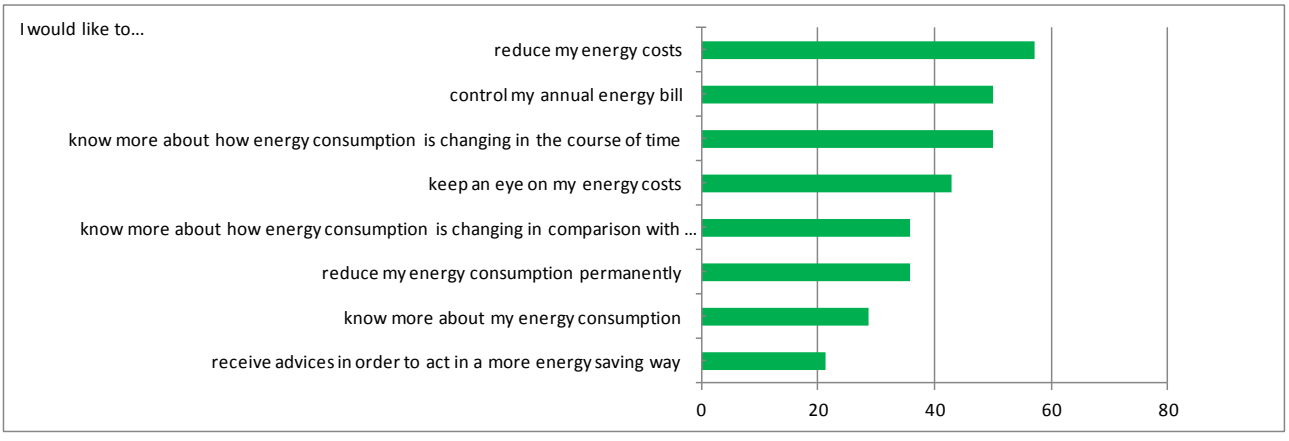
The motivation at the final stage shows a slight shift towards the environmental aspect which seems to be more pronounced in the experimental group with a now smaller proportion of the motive “saving money solely” (1 tenant, 5%) and a bigger proportion for “saving money more than protecting the environment” (7 tenants; 35%). At the same time one tenant mentioned that the only motivation is to protect the environment what at baseline stage nobody stated.

Among the active users all motives are represented. As in the total experimental group, at final stage the majority of active users assessed both aspects as equally important in order to save energy.

Reasons for using and for not using the tenant portal

The most important reasons for portal use cover three aspects. These are the reduction of energy costs, the control of the annual energy bill and to know more about the development of energy consumption in the course of time. At least 50% active users strongly agree with these aspects. Reasons such as reducing the energy consumption or knowing more about it range further down. As already seen in other pilot sites, advices for acting in a more energy saving way are of little relevance for the tenants.

Figure 4.6.11: Reasons for using the tenant portal
(n=14; active users; percentages for “strongly agree”)



Survey question: There are different reasons for using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don’t know.

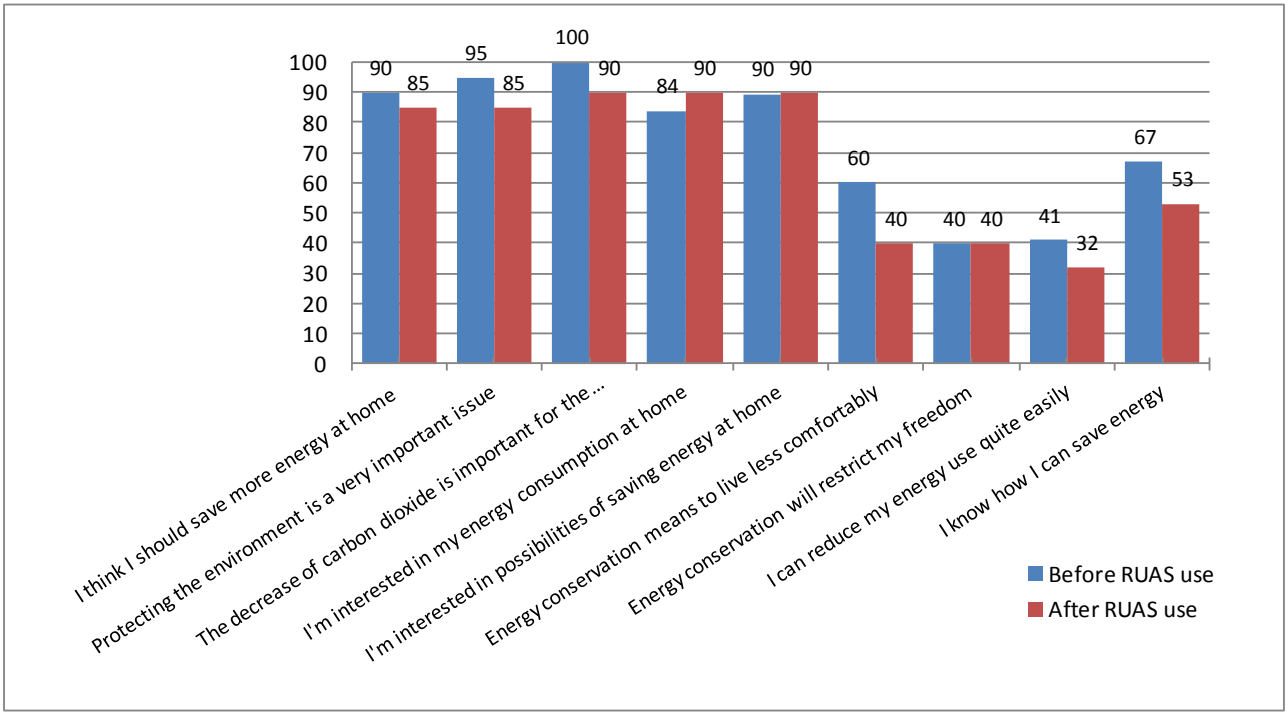
The seven tenants of the experimental group who do not use the portal actively were asked for their reasons. Based on the answer categories “strongly agree” and “rather agree” there are four reasons that are important for more than one person. Three tenants prefer paper information. In

each case two tenants are of the opinion that they know enough and therefore do not need further information resp. are not interested in or cannot use the internet. This shows that some tenants could be attracted by providing paper reports. For other tenants a lack of motivation is the main obstacle which can hardly be influenced.

Impact on ecological awareness

Figure 4.6.12 shows the development of ecological awareness in the experimental group. In general, only small developments can be found because of high ecological awareness at baseline stage as well as final stage. In addition to that, differences up to ten percentage points (which means that maximally two persons changed their opinion) should not be overvalued due to the small sample size

Figure 4.6.12: Ecological awareness of experimental group tenants before and after RUAS use
(n=17-20 due to missing values); percentages for answer categories "strongly agree and rather agree")



Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

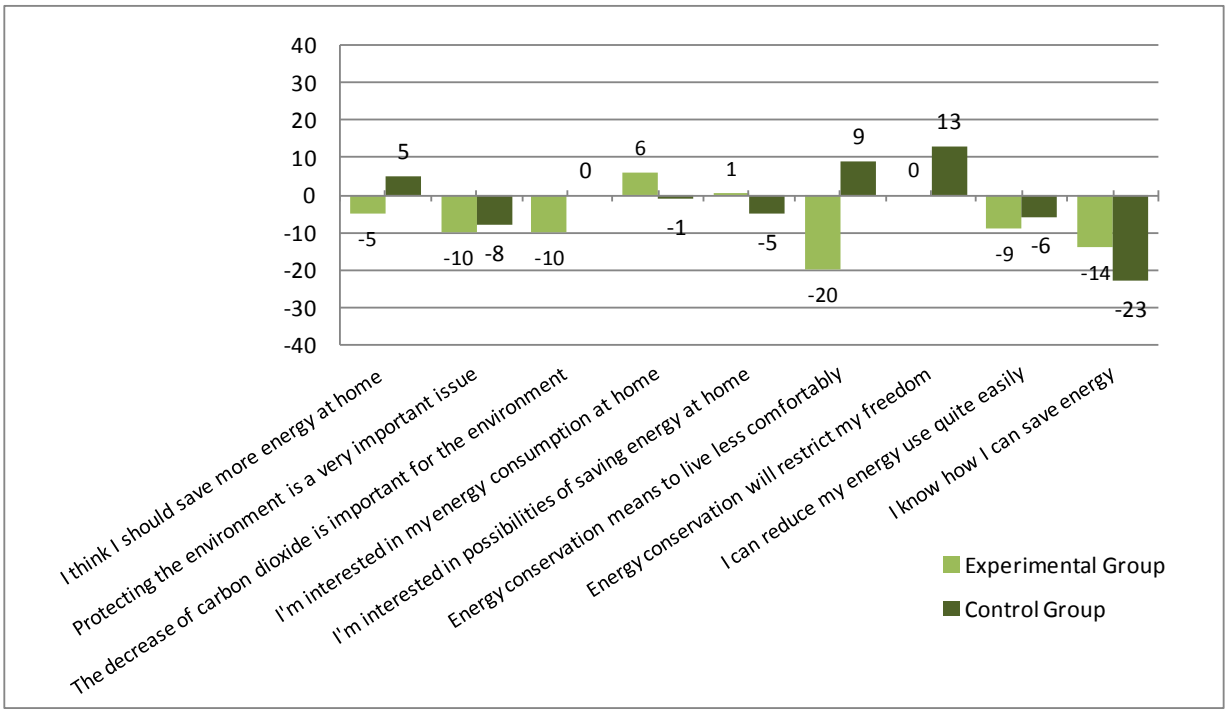
The figure shows that the tenants are very aware of the need and the importance of environment protection and are taking responsibility when saving energy at home. In parallel it becomes obvious that energy conservation is rather not restricting comfort of freedom, but it is also not easy to realise, even if some knowledge about how to be able to save energy does exist.

Noticeable trends can be found for two statements. The conviction that energy conservation means to live less comfortably declines from 60% to 40%. That describes a positive trend as there is no risk that energy conservation actions are neglected due to this reason. On the other hand, the knowledge about how to save energy also decreased by 14%-points. Due to the low sample size these results should be not overvalued.

In the control group there is also a high level of ecological awareness visible. The changes are rather small and mostly similar to the experimental group. The only statements with different trends are the same ones as above, but additionally cover the opinion that energy conservation will restrict one's freedom. That impression of restrictions related to comfort and freedom increases in the control group in the course of time, but didn't apply to the experimental group with decreased or unchanged (rather low) level. This means that the RUAS services might strengthen the opinion

that energy conservation is not necessarily related to restrictions. The knowledge about how to save energy is decreasing in both groups, but even more in the control group than in the experimental group.

Figure 4.6.13: Changes of ecological awareness of experimental group and control group tenants
(n=17-20 (exp.) and 48-61 (contr.) due to missing values[91]; pre-post comparisons; percentage point differences for answer categories "strongly agree and rather agree")



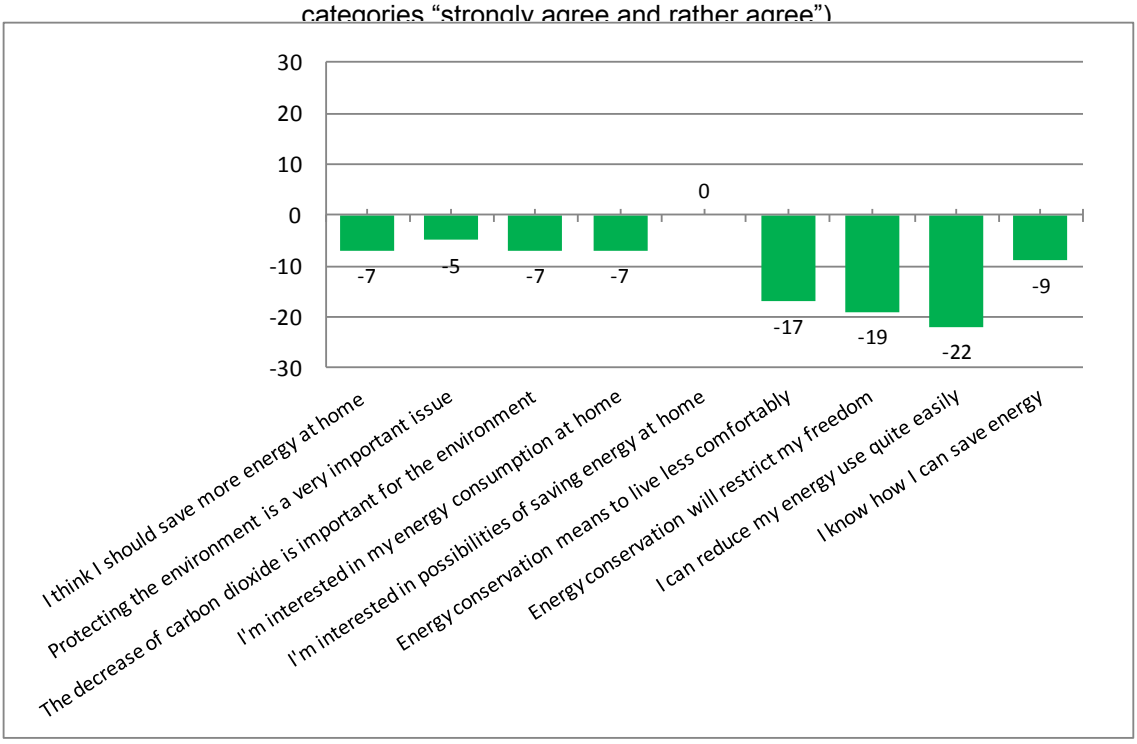
One explanation for these results might be that environment protection and energy conservation are topics in Ruse / Bulgaria that are present and pushed on a national or regional level intending to motivate the citizens to take actions and therefore the ecological awareness of all tenants is high. So the decrease of the opinion that energy conservation is restricting could be interpreted as positive influence of the RUAS services.

The decrease of knowledge how to save energy might be caused by the fact that tenants assess the currently available knowledge one can have. Maybe as a result of the services they recognized that there are more topics of interest in the context of saving energy than they assumed at baseline stage.

Furthermore, Figure 4.6.14 shows that the ecological awareness is generally somewhat higher in the control group than in the experimental group, but some positive influences of the RUAS services can be found if initial situations and trends over time are considered. So the differences between both groups became smaller for the statements "I'm interested in my energy consumption at home" and "I'm interested for possibilities of saving energy at home". The opinion that energy conservation means to live less comfortably was more widespread in the experimental group than in the control group at baseline stage, whereas at final stage it is the other way round.

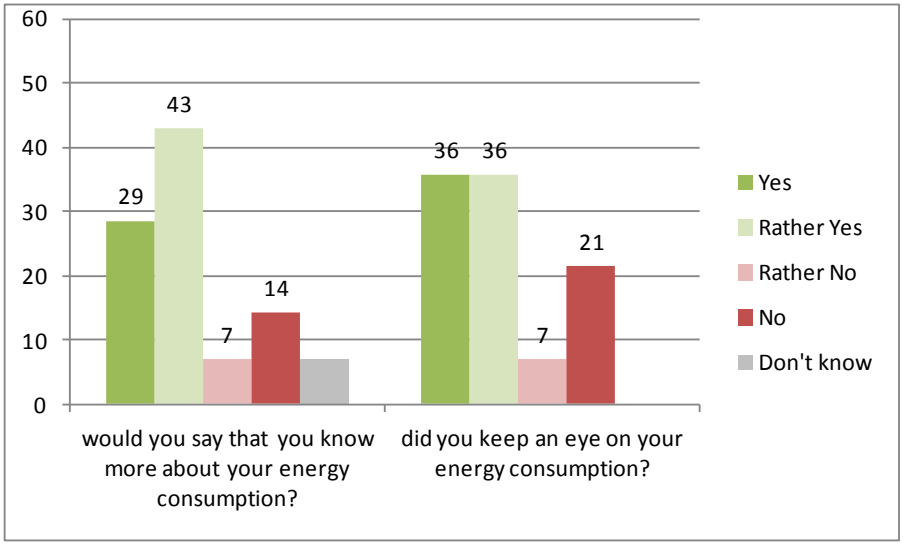
[91] Answer categories „not applicable" and "don't know" were coded as missing.

Figure 4.6.14: Differences between experimental group and control group at final stage
(n=17-20 (exp.) and 48-61 (contr.) due to missing values [92]; percentage point differences for answer categories "strongly agree and rather agree")



At the same time the difference between both groups related to the statement "Energy conservation will restrict my freedom" enlarged whereas the difference related to the knowledge about how to save energy diminished. These results can be interpreted as influences that are mainly due to the RUAS.

Figure 4.6.15: Knowledge and relevance of energy saving issues resulting from RUAS use
(n=14; percentages)



Question: Thinking of the provided tenant portal…
- would you say that you know more about your energy consumption?
- did you keep an eye on your energy consumption?
Answer categories: "Yes", "Rather yes", "No", "Don*t know".

[92] Answer categories „not applicable" and "don't know" were coded as missing.

When examining knowledge and relevance of energy saving issues in more detail from the retrospective perspective of the active users, it becomes obvious that the majority is of the opinion to now know more about their energy consumption. Four tenants are very sure about this fact (answer category “yes”), six tenants are rather sure (“rather yes”). In contrast, only three tenants do (rather) not think that they increased their knowledge, one person is not decided.

A similar result is related to the relevance of energy consumption. Ten tenants reported to keep an eye on their energy consumption (“rather yes”: 5 tenants, “yes”: 5 tenants). Four tenants are of another opinion (“rather no” and “no”).

This shows a positive influence that is attributed to the tenant portal from the tenants’ perspective.

In summary, the results related to the ecological awareness show a meaningful influence that is assumed to be mainly caused by the RUAS services – even if influences on the awareness trends are not very obvious (pre-post comparisons). It has to be noticed that a positive influence is not always manifested in an increase of the “desired” pro-ecological opinion, but also in a decrease of opinions that suggest less ecological awareness. This has to be interpreted under consideration of the trends in the control group. Several positive results could be noticed. As tests of statistical significance were not possible due to the small sample, it cannot be excluded that other factors than the RUAS services may also play a role for the results given.

Impact on ecological behaviour

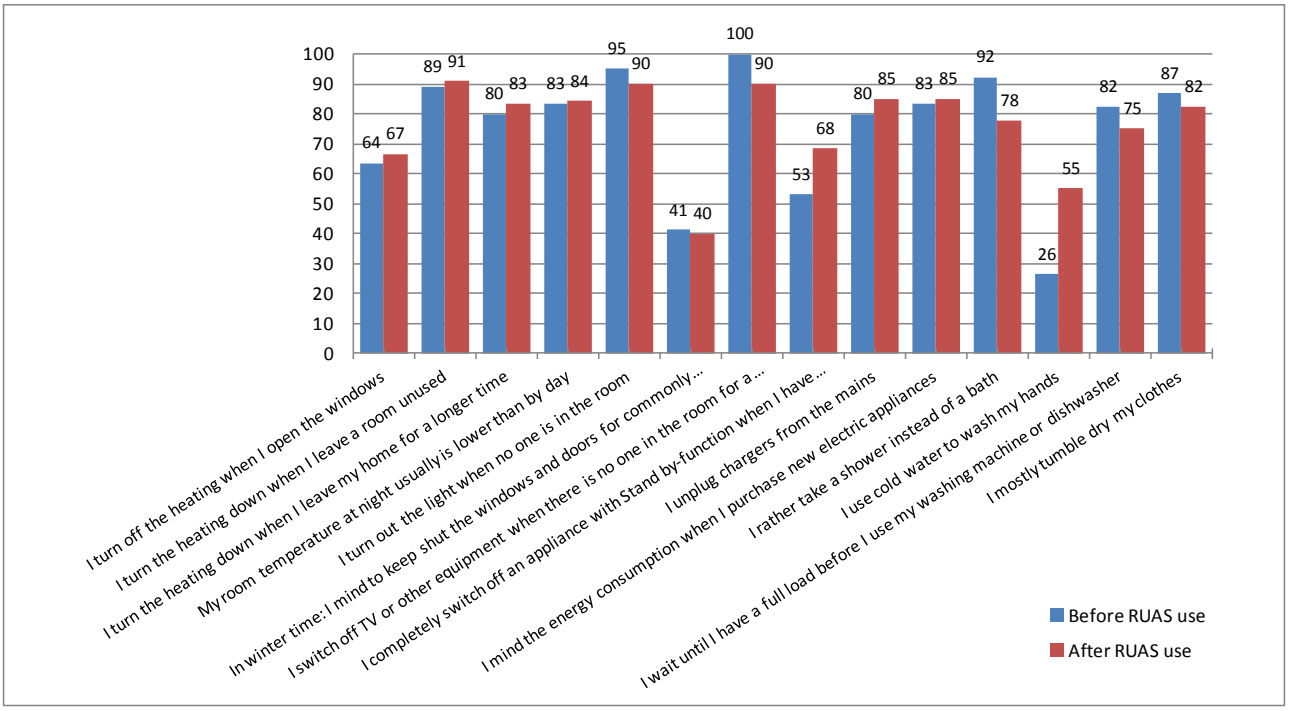
The following figure shows ecological behaviour patterns before and after the RUAS use. Related to the majority of statements it is to be seen that tenants already behaved in a pro-ecological manner prior the RUAS operation. However, for most statements there are further increases obvious.

The largest positive trends can be found regarding statements with comparably lower baseline levels such as “I completely switch off an appliance with stand by-function when I have finished using it” or “I use cold water to wash my hands”. In these cases the proportion of agreement increased by 16%-points and 29%-points.

On the other hand there are few statements with a decrease of ecological behaviour as, for example, “I switch off TV or other equipment where there is no one in the room” or “I turn out the light when there is no one in the room”. These are statements with already very high baseline levels (up to 100%) with no or very less potential for improvement. This shows that the RUAS services contributed mainly to aspects with potential for improvement.[93]

[93] The decrease related to “I rather take a shower instead of a bath” can be partly explained by different sample sizes before and after RUAS use.

Figure 4.6.16: Ecological behaviour of experimental group tenants before and after the use of RUAS
(n=9-20 due to missings[94]; percentages for answer categories “strongly agree and rather agree”)



In figure 4.6.17 can be seen that the trends of ecological behaviour in the experimental group and in the control group are mainly different, even if there are some statements with rather small differences.

In some cases the experimental group shows large positive trends whereas the trend in the control group is negative:

- “I completely switch off an appliance with stand by-function”;
- “I use cold water to wash my hands”

In other cases the positive trend in the experimental group is rather small or nearly unchanged, but the control group also shows a considerably negative trend:

- “I turn the heating down when I leave a room unused”,
- “I mind to keep shut doors and windows for commonly used rooms in winter time”,
- “I mostly tumble dry my clothes”).

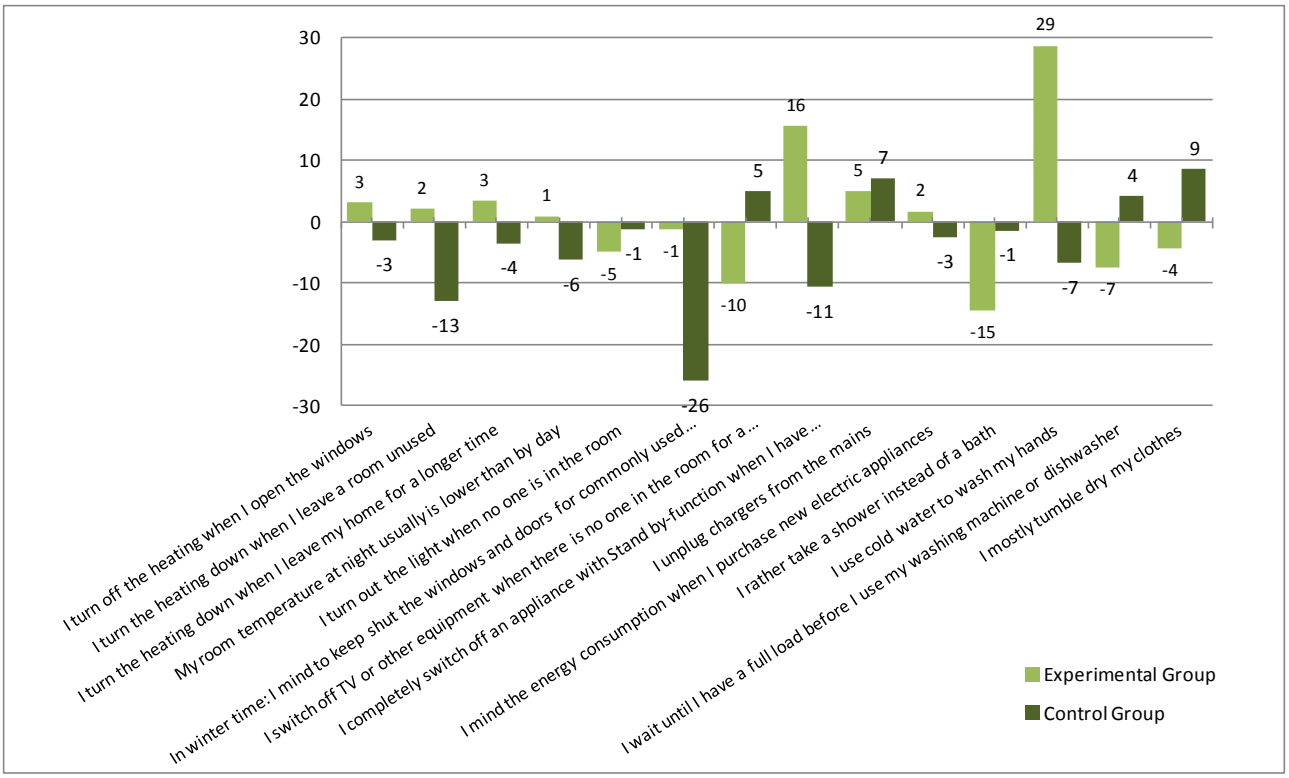
Both findings indicate the positive RUAS influence on the respective behaviour patterns. However, there are two statements without improvements of the experimental group compared the control group. This is true for

- “I wait until I have a full load before I use my washing machine or dishwasher” and
- “I switch off TV or other equipment when there is no one in the room”.

Again the trend of the last-mentioned statement can be explained by the missing potential for improvement because all tenants already behaved optimally prior the RUAS use.

[94] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.6.17: Changes of ecological behaviour of experimental group and control group tenants (n=9-20 in exp. group and 43-61 in contr. group due to missing values[95]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)



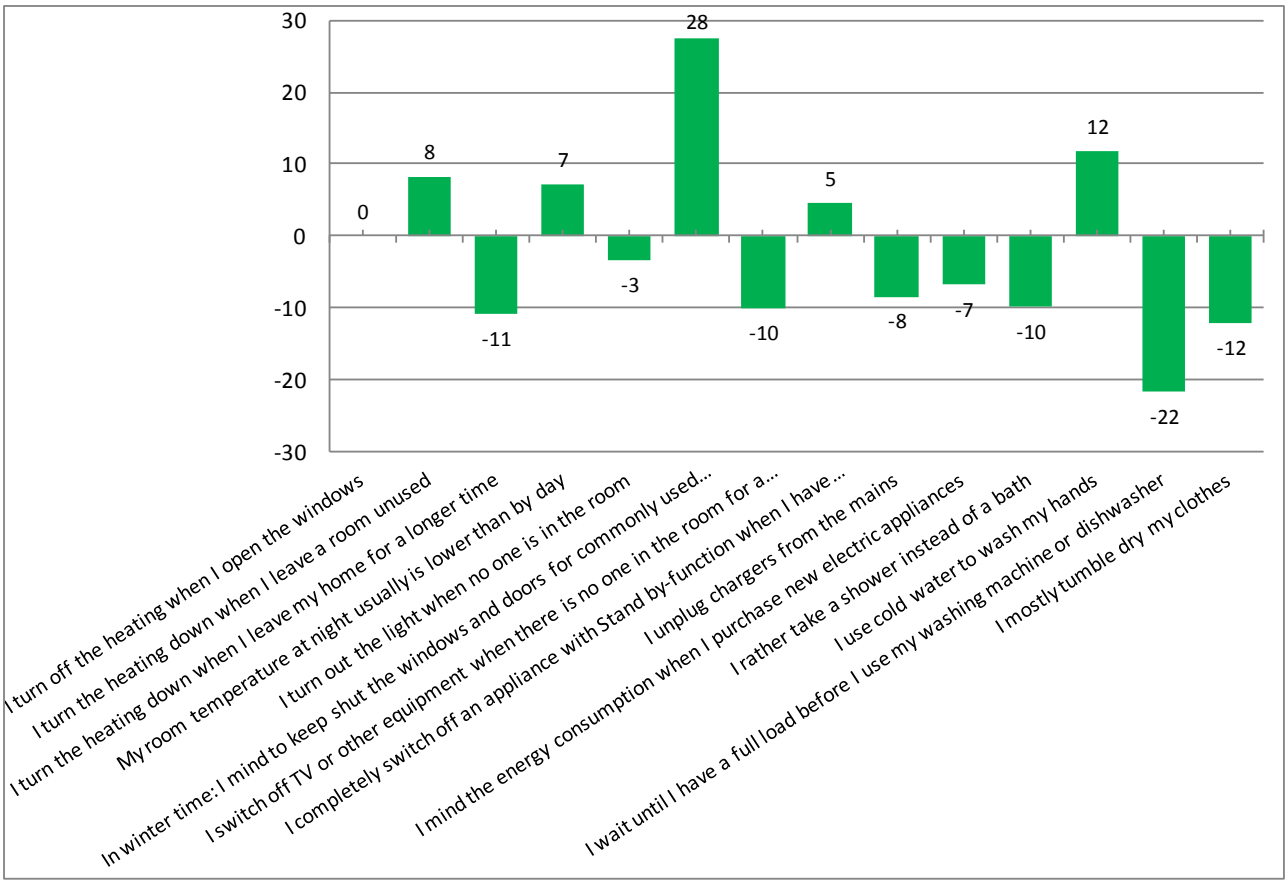
The trends of both groups result in the following behaviour at final stage (Figure 4.6.18). At first glance there is positive result related to six statements only with better performance of the experimental compared to the control group. But when taking the initial situation into account the changes of more statements have to be interpreted positively mainly caused by the RUAS services. This is true for

- “I turn off the heating when I open the windows”,
- “I turn the heating down when I leave my home for a longer time”,
- “I mind the energy consumption when I purchase new electric appliances”.

Indeed, in these cases the experimental group showed more seldom pro-ecological behaviour prior the RUAS use than the control group, but the difference diminished strongly when using it. In total, for the majority of statements there is strong evidence that the RUAS services contributed to the improvement of ecological behaviour in the experimental group.

[95] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.6.18: Differences between experimental group and control group at final stage
(n=11-20 in exp. gr. and 51-61 in contr. group due to missings[96]; percentage point differences for answer categories “strongly agree and rather agree”)



Ventilation behaviour

The following figures show the ventilation behaviour of both groups at final stage regarding tenants participated at least in the final survey.[97] It becomes obvious that the experimental group ventilates much more often in an ecological manner than the control group. Tenants of the experimental group mainly open windows widely at times in all rooms as recommended. At the same time no tenant of the experimental group leaves windows ajar often or all times which would be the worst option from an ecological view. On the contrary, only few tenants of the control group open windows widely at times. Often or permanent tilt ventilation is a more frequent. Although the majority of control group tenants leave windows ajar at times only and not longer than at least one hour a day, the differences between both groups are striking and support the efficacy of the RUAS.[98]

[96] Answer categories „not applicable” and “don’t know” were coded as missing.

[97] A pre-post comparison is not possible due to a question modification at final stage.

[98] As the question about ventilation in bathrooms is only appropriate for three tenants of the experimental group, an analysis for this room is not useful.

Figure 4.6.19: Ventilation behaviour of exp. group tenants in winter time (final stage)
(n=10-24 due to missings[99]; percentage)

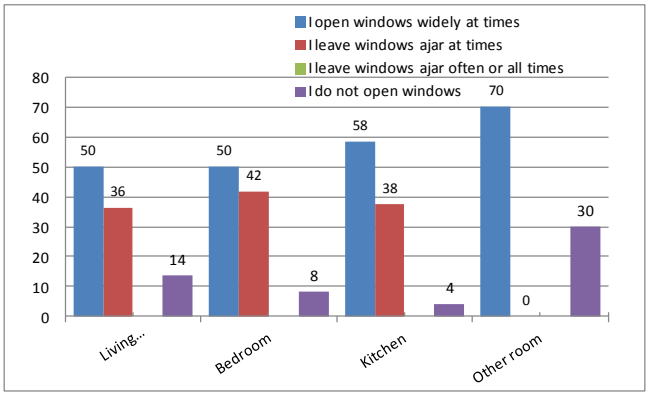
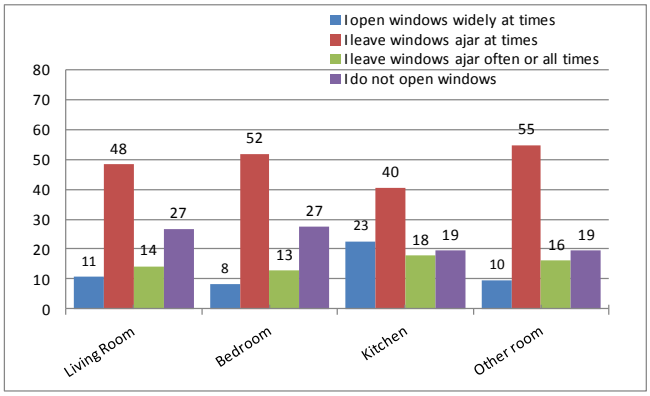


Figure 4.6.20: Ventilation behaviour of control group tenants in winter time (final stage)
(n=31-62 due to missings[100]; percentage)



Room temperature and use of air conditioning

In winter time the room temperature of much used rooms is before and after the use of the RUAS services about 22 degree in the experimental group which is a rather high value. In the control group the temperature is even higher and with 22 degrees at baseline stage and 23 degrees at final stage. In little used or unused rooms there are much lower room temperatures. In the experimental group the temperature is about 17 degree at baseline and final stage, in the experimental group it is about 19 degree at baseline stage and 17 degree at final stage.

In general, there cannot be found an influence of the RUAS services on the room temperatures which are still rather high in much used rooms. This can be due to the fact that the need for warm temperatures is rather high in both groups. At the same time it has to be mentioned that the analyses base on a small sample. Many tenants do not know their room temperatures and therefore the results are prone to extreme values.

In Ruse, nearly half of all tenants have got an air conditioning system and therefore have been asked about their room temperatures in summer time. The duration of usage of the air conditioning was also of interest.

Among the tenants with an air conditioning system high room temperature in much used rooms can be found – within the experimental group about 28 degree at baseline stage and 25 degree at final stage. In the control group the temperature is about 26 degree at baseline stage and 25 degree at final stage. It has to be noticed that these results base on a very small number of cases as only five tenants of the experimental group have got an air conditioning system and know the room temperature. But due the reasons mentioned and the fact that tenants of the experimental group by tendency spend longer time periods at their homes (see table 4.6.9), this result can hardly be interpreted.

The use frequency of the air conditioning system is basing on the reports of six tenants of the experimental group and 26 tenants of the control group and therefore has also a limited significance. At baseline stage, the majority of experimental group tenants makes use of the air conditioning less than one hour a day (4 out of 6 tenants) while the control group is split into two subgroups: 46% of the tenants (12 out 26) also makes use of it less than one hour a day; the other subgroup makes use of it more than eight hours a day (11 out of 26 tenants). At final stage, the extreme poles of the control group approached as 47% make use of the air conditioning 1-3 hours a day and further 30% (9 tenants) use it 4-8 hours a day. Only two tenants use the air conditioning

[99] Answer category „not applicable/no window in room" was coded as missing.

[100] Answer category „not applicable/no window in room" was coded as missing.

less than one hour a day, five tenants use it more than eight hours a day. In the experimental group most tenants use the air conditioning 1-3 hours or 4-8 hours a day (3 out of 7 tenants in each case) while no tenant used it longer than eight hours a day. So, the difference is made by the five control group tenants that belong to the heavy users of the air conditioning (more than 8 hours a day). This heavy use of control group tenants is not due to shorter absences of all household members from their homes. However, this result can hardly be interpreted as (partly) influence resulting from the RUAS services.

Retrospective and prospective behaviour

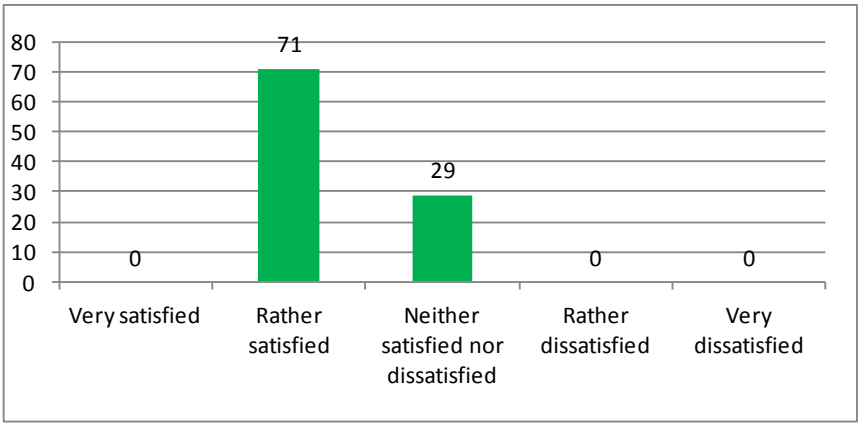
Although the active portal users do not think that they changed their energy consumption as a result of the portal usage (8 tenants state “no”, 6 tenants state “don’t know”), except one tenant all others intend to conserve heat energy next winter (11 tenants state “yes”, 2 tenants state “rather yes”).

In summary, it can be see that the RUAS has an impact on the tenants’ behaviour. Influences were found related to several everyday behaviour patterns with a RUAS contribution to the increase of the ecological behaviour in the experimental group. A rather large influence is found for the ventilation behaviour. The results regarding room temperatures and the use of the air conditioning system show no clear tendency. This might be mainly due to the small sample sizes.

Satisfaction with tenant portal

Even if nobody of the active users is generally very satisfied with the tenant portal, a global satisfaction is given with 71% rather satisfied tenants (10 out of 14). Four tenants are neither satisfied nor dissatisfied and nobody states to be dissatisfied.

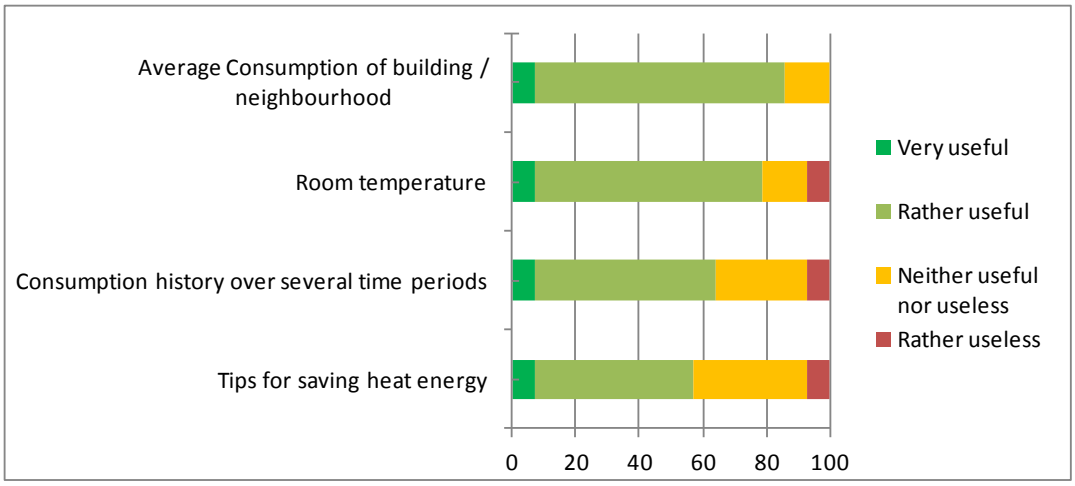
Figure 4.6.21: General satisfaction with tenant portal (n=14; percentage)



Question: How satisfied are you with the services of the tenant portal in general?

The evaluation of the usefulness of the information presented confirms the results about the general portal satisfaction. This means that there are few tenants considering the information very useful, but a lot of tenants who find it rather useful. Based on the answer categories “very useful” and “rather useful” the average consumption of the building is most useful information, followed by the room temperature. But also the consumption history over several time periods and tips for saving heat energy are predominantly assessed as useful.

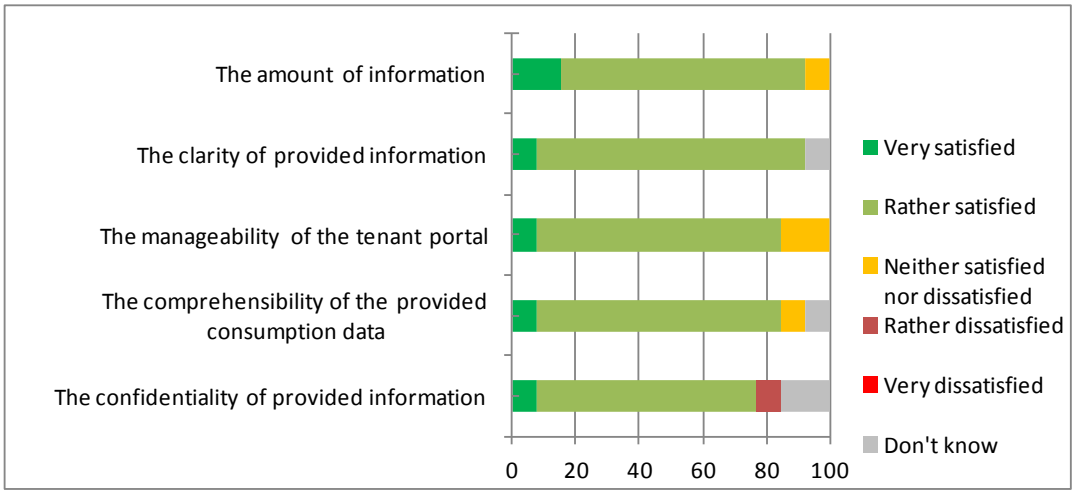
Figure 4.6.22: Usefulness of information presented in the tenant portal (n=14; percentage)



Thirteen tenants evaluated further aspects dealing with the handling of the tenant portal and its information. As before, most tenants are rather satisfied with the single aspects. Especially the amount of information and the clarity of the provided information are evaluated as satisfying. But the majority of active users are also satisfied with the manageability of the portal and the comprehensibility of the provided data. The confidentiality of the provided information receives slightly lower satisfaction scores, but these are mainly due to a higher percentage of tenants who don't know whether they are satisfied or not.

These results show that the satisfaction of tenants probably could be improved by receiving further advices or trainings about how they can successfully use the tenant portal.

Figure 4.6.23: Satisfaction with handling of the tenant portal (n=13; percentage)



Prospective portal use and willingness to pay

All of the 14 active users intend to use the tenant portal frequently in future which can be seen as great success of the portal. This means that being "only" rather satisfied with parts of the portal, does not prevent them from further usage.

However, only two tenants are willing to purchase an energy monitoring device that is comparable to the tenant portal. Both would pay ten Bulgarian Lew per month which corresponds to about five EUR.

In summary, the active users are rather satisfied with the tenant portal, the information presented and the handling of the portal. The success of the portal can also be seen in the fact that all tenants intend to use it also in future – even if only two tenants are willing to pay for it.

4.6.4 Results of combined analysis

In Ruse the combined analysis of survey data and consumption data includes electricity and cold water consumption. It will give further details about the water consumption per capita for the subsample of tenants who reported the household size in the survey.

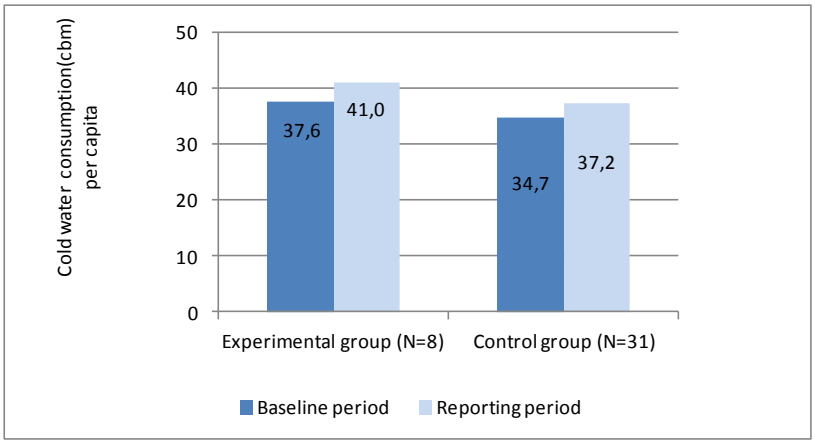
As the retrospective questions related to ecological awareness and knowledge showed a sufficient range of answers, the retrospective view will be analysed related to the achieved savings.

Additionally the electricity consumption which is used for space heating, electrical appliances and partly for air conditioning is analysed in detail on the basis of further information gathered in the survey.

Water consumption per capita

The household size is only known from respondents of both survey stages. The average consumption per capita is shown in the following figure.

Figure 4.6.24: Average cold water consumption per capita related to user groups

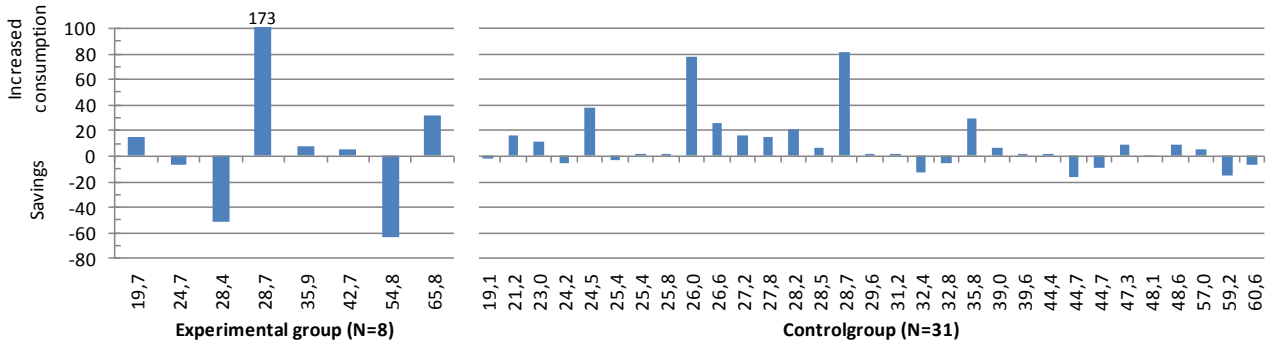


It becomes obvious that the experimental group tenants consumed more cold water in the baseline period than the control group. In both groups the consumption increased during the project. This means that an influence of the RUAS on cold water consumption is not reflected when examining the water consumption per person.

When calculating the average percentage changes of both groups, the control group shows an averaged increased consumption of 9.6% and the experimental group has an increased average consumption per person of 14.1%. But as the following figure shows the consumption increase of the experimental group is mainly due to one extreme value with an increased consumption of 173% when turning the rather low baseline consumption into a rather high consumption in the reporting period (78.5m^3/person). This case carries significant weight in the calculation of the average percentage change due to the very low sample size of the experimental group (n=8).

With respect to the control group, the figure shows that the savings are related to the baseline consumption: High consumers achieved more often savings or show smaller increases than low consumers. In total, three of eight tenants of the experimental group (37.5%) and 32.3% tenants of the control group achieved savings. In addition to that, the average savings of the experimental group are much higher than in the control group (-40.2% versus -7.6%). But due to the small sample size of the experimental group this results should be treated carefully.

Figure 4.6.25: Percentage change in cold water consumption for experimental group and control group related to baseline cold water consumption (in m^3/person)

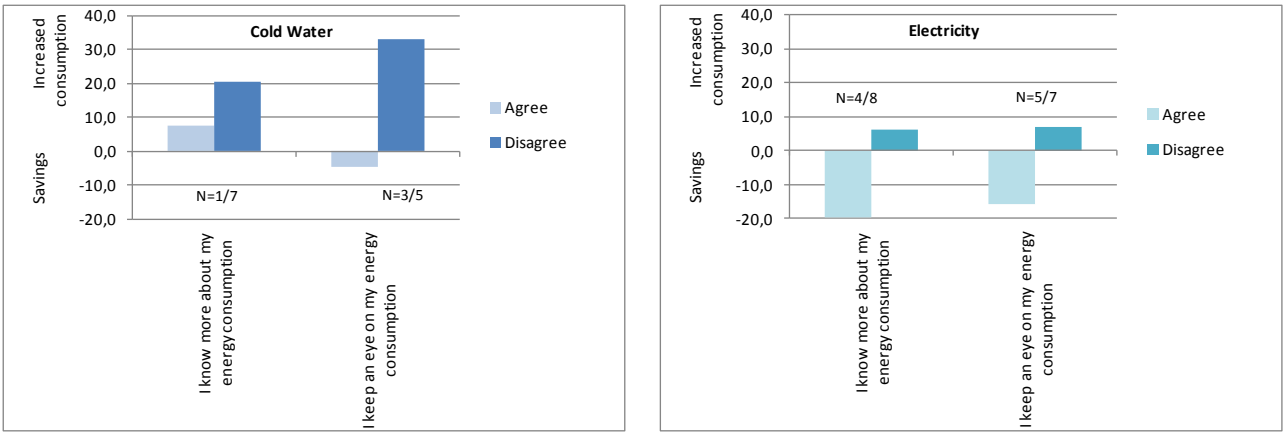


Retrospective ecological awareness / behaviour and energy consumption

The data in Ruse allows for assessing the relation between two retrospective questions the active users have been asked for and the percentage changes in electricity consumption and cold water consumption per m^2.

It is examined if tenants who agree with the items performed better than tenants who disagree.[101] The items under consideration focus on the ecological awareness respectively knowledge (knowing more about energy consumption due to the provided tenant portal) and the ecological behaviour (keeping an eye on energy consumption due to the provided tenant portal).

Figure 4.6.26: Percentage change in cold water and electricity consumption with and without retrospective ecological awareness resp. behaviour



As the above figure shows, tenants who agree with the items performed better than tenants who disagree. This is especially true for electricity consumption with somewhat bigger sample size. Tenant who agreed saved up to 20% electricity. Tenants who disagree have an increased consumption of up to 6%.

With respect to water consumption (per m^2) the same result can be found for the item “I keep an eye on my energy consumption”. The other item shows less influence, but this is – due to the small sample size – not as meaningful.

[101] An agreement includes answers categories „yes“ and „rather yes“; a disagreement includes answer categories „no“ and „rather no“.

These results show that the RUAS not only contributed to a change of tenants' ecological knowledge and behaviour, but also that these changes are relevant for the achievement of savings.

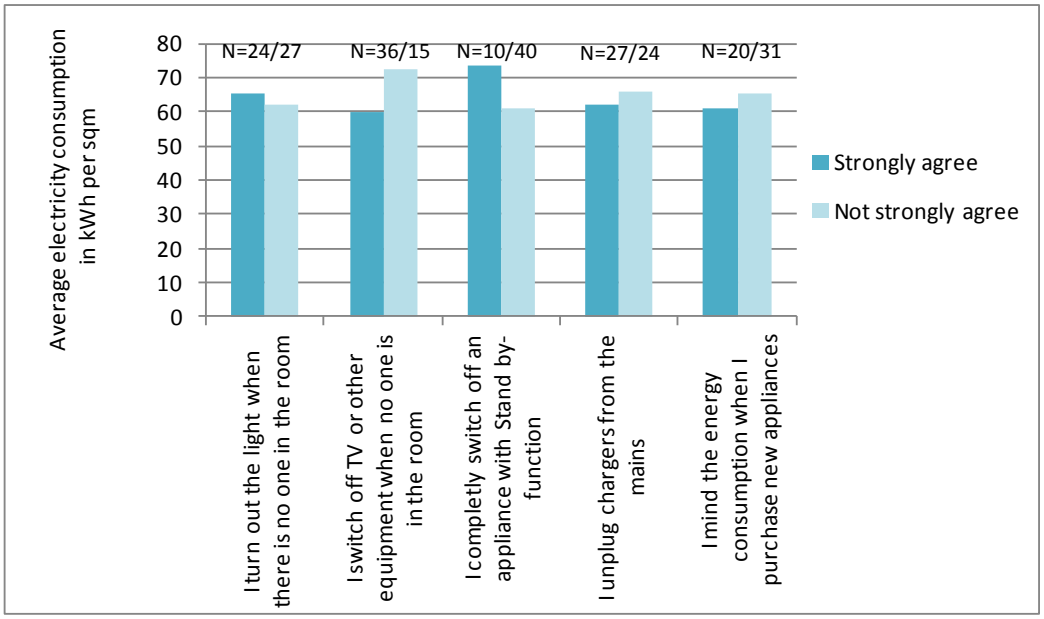
Everyday ecological behaviour and electricity consumption

In Ruse electricity consumption is used for space heating, electrical appliances and air conditioning which is available in some dwellings.

The following section assesses the relation between the ecological behaviour in those domains (heating, appliances), the availability of air conditioning and electricity consumption respectively savings or increases.

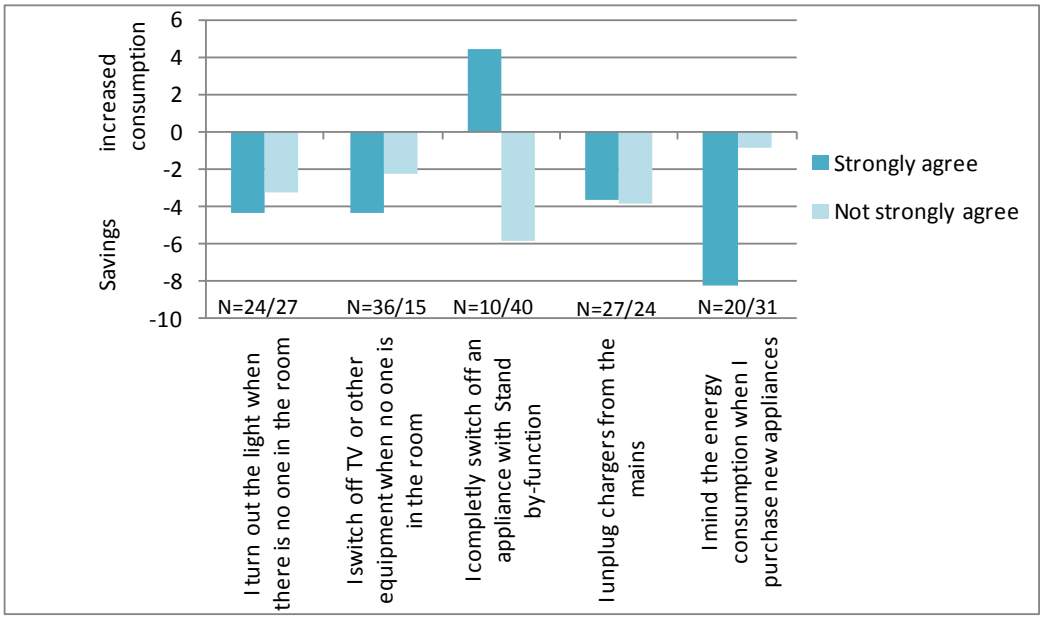
According to the following figure, electricity consumption in the reporting period not generally depends on ecological behaviour (reported at the final stage) that is related to the use of appliances or lighting.

Figure 4.6.27: Electricity consumption (reporting period) of respondents with and without ecological behaviour (related to the use of appliances; lighting) reported in final survey



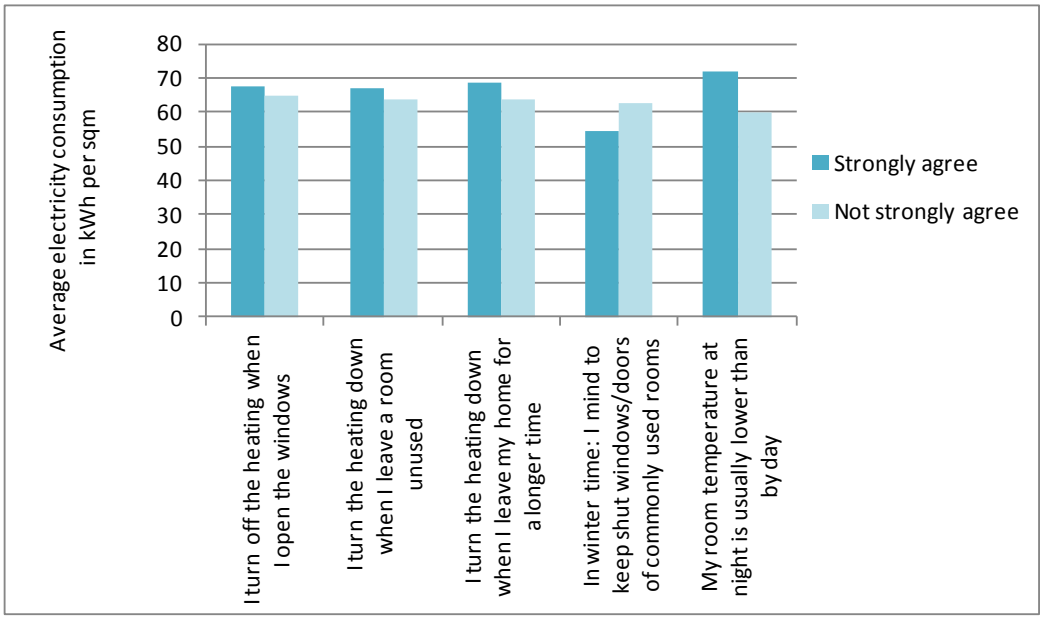
However, when considering the percentage changes instead of the consumption during the reporting period, the results suggest that a pro-ecological behaviour contributes to higher savings in electricity consumption. Only one behaviour item (I completely switch off an appliance with Stand by-function) shows a deviating result.

Figure 4.6.28: Percentage changes in electricity consumption of respondents with and without ecological behaviour (related to the use of appliances; lighting) reported in final survey



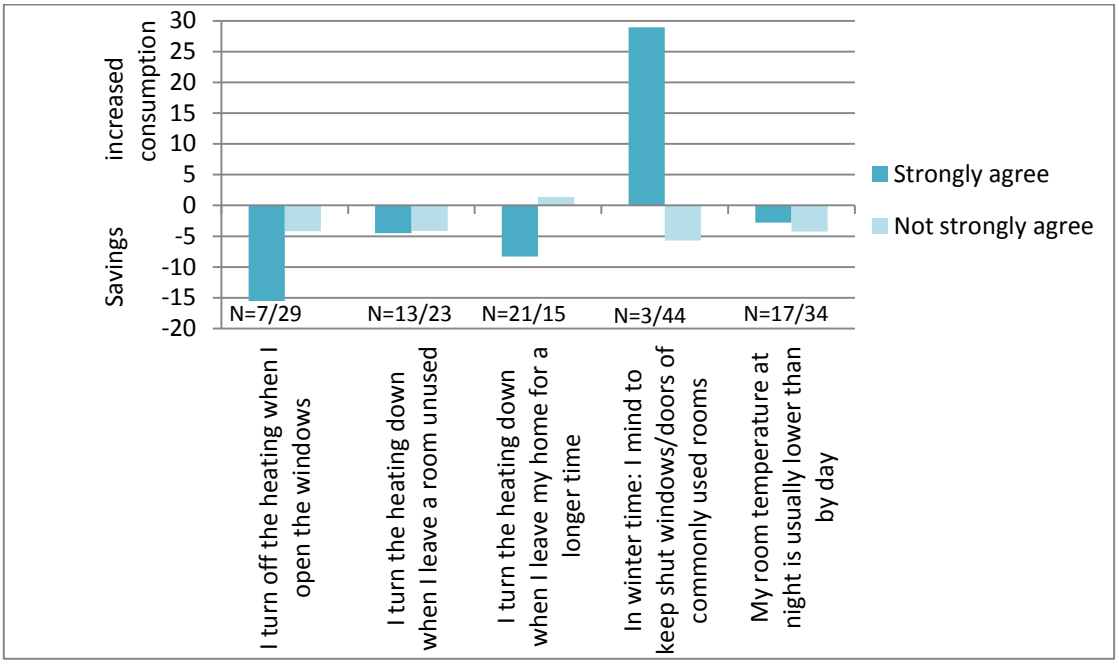
Considering the behaviour items related to heat energy, there cannot be found a major influence on electricity consumption in the reporting period. Generally, tenants with ecological behaviour consumed somewhat more energy than tenants without ecological behaviour.

Figure 4.6.29: Electricity consumption (reporting period) of respondents with and without ecological behaviour (related to heat energy) reported in final survey



Considering again the percentage changes in electricity consumption, it can be seen that tenants with ecological behaviour mostly performed better than tenants without ecological behaviour. As before, there is only one item showing a different result (“I mind to keep shut windows/doors of commonly used room”). But due to the small sample size regarding this item, the result should be treated carefully.

Figure 4.6.30: Percentage changes in electricity consumption of respondents with and without ecological behaviour (related to heat energy) reported in final survey



In summary, the findings suggest that the behaviour related to appliances/lighting and the behaviour related to heat energy both have an influence on the achieved savings – despite of the partly existing higher consumption in the reporting period of tenants who behave in an ecological manner. This means that trying to influence the tenant's behaviour which is partly worked out at the RUSE pilot site is a usable way to achieve a reduction of electricity consumption.

Electricity consumption and air conditioning

It is assumed that the availability of an air conditioning system is strongly related to the electricity consumptions of the tenants. According to the final survey, nearly half of the respondents own an air conditioning system which shows the relevance of this topic for the electricity consumption.

Among the dwellings with available electricity consumption, 21 tenants have got an air conditioning system and 30 tenants have not.

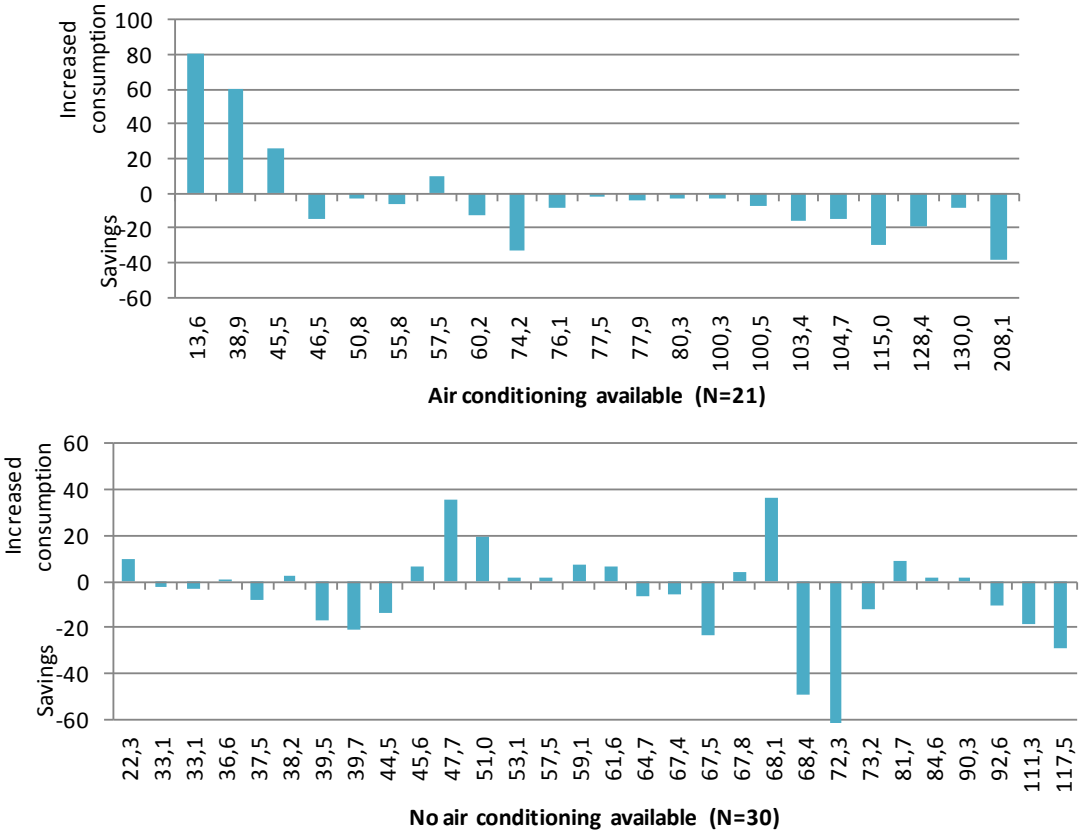
Tenants with air conditioning system consumed 73.8 kWh/m^2 on average which is much more compared to tenants without air conditioning systems who consumed 56.7 kWh/m^2.

Considering the percentage changes related to the availability of an air conditioning system it can be seen that both tenant groups achieved savings, but the average savings of tenants without air conditioning are higher (-4.9%) than for tenant with air conditioning (-2.1%).

As the following figure shows, the achievement of savings is related to the electricity consumption in the baseline period. Especially high consumers achieved savings. This is especially true for tenants with an air conditioning system. Independent from the baseline consumption, 81% of the tenants with air conditioning achieved savings (on average -13.0%), but only 50% of tenants without air conditioning (on average -19.4%). In addition to that, tenants of the experimental group who possess an air conditioning consumed 18.9% more energy whereas experimental tenants without AC achieved savings of 3.0%. On the contrary, tenants of the control group without air conditioning saved 6.4% and with AC 10.5%.

This means that future RUAS services should focus on the usage of an air conditioning system as there seems to be a high potential for savings.

Figure 4.6.31: Percentage changes in electricity consumption of respondents with and without air conditioning system reported in final survey

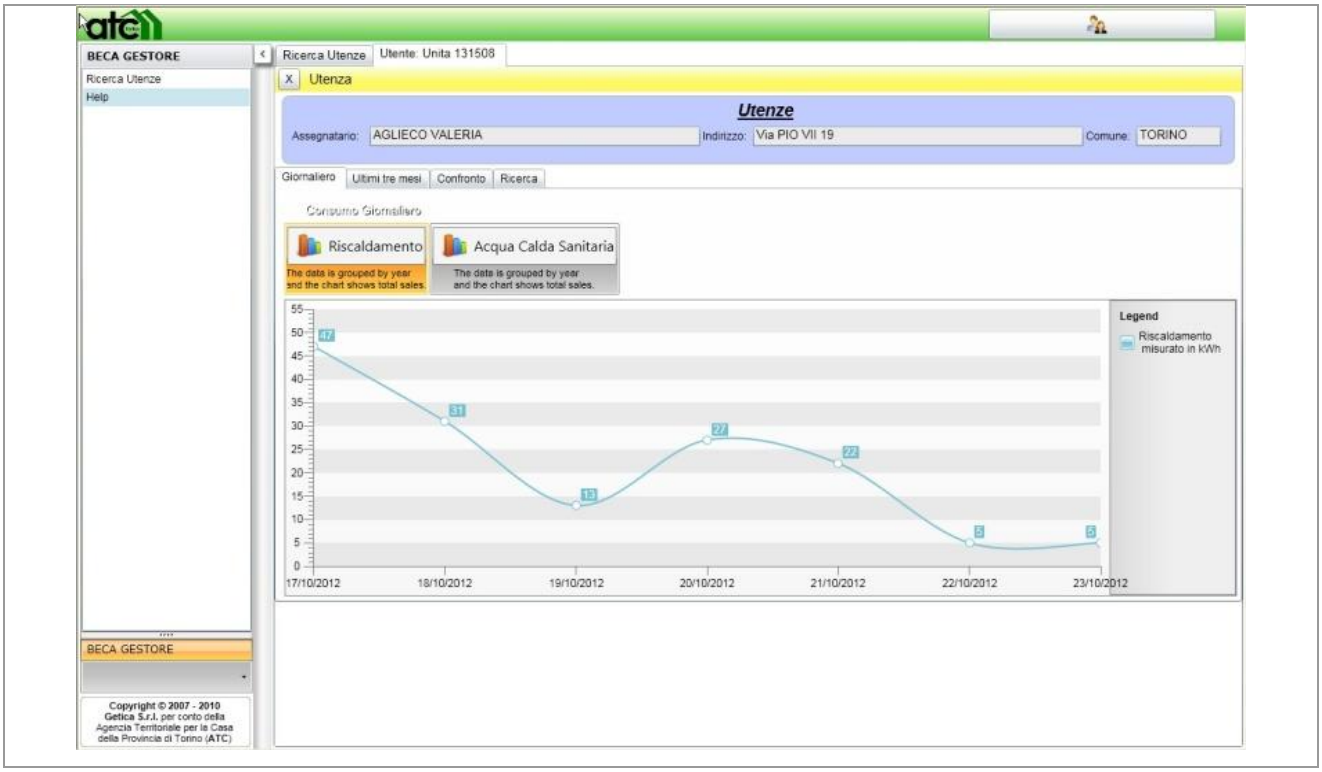


4.7 Torino

4.7.1 Background information

Torino implemented a RUAS at all three pilot sites and a RMS related to heating at the site Orbassano. The RUAS was available in two main setups: All experimental tenant households could receive feedback on their current heat energy and hot water consumption.[102] Additional feedback on their monthly cold water consumption was available in two of the three sites (MOI, Spina 3). Tenants were enabled to monitor their consumption (without expenditures) and could receive additional coaching from ATC if needed. In cases of high consumption, alerts were given via e-mail. Monthly reports have been provided via e-mail respectively enclosed in the postal bill.

Figure 4.7.1: Screen shot of the RUAS tenant portal



The RMS (Techem Adapterm system), installed in Orbassano only, automatically sets the supply temperature according to the needs of the tenants. It serves as a monitoring system and allows annual inspections of the thermal energy delivered to the building (heating and DHW) and optimisations of the system.

Both RUAS and RMS started operation in October 2012 – after a one-year baseline consumption measurement (Nov 2011 – Oct 2012) and followed by a one-year reporting period (Nov 2012 – Oct-2013). That allows pre-post comparisons based on the analysis of the evolution of the consumption figures respectively the in tenant surveys reported behaviour patterns / attitudes before and after the implementation of the service. The comparably 12-month lengths of both periods enable to have a good consistency of consumption data.

In addition to that, the Torino pilot evaluation followed a control group approach. The following table shows in detail the number of dwellings and the allocation to experimental or control group

[102] In Spina 3 there was a combined feedback of space heating and water heating available. In MOI a metering system failure restricted the validity of the reported data (see further explanation in the text).

related to the different service setups (energy / resources included). A short summary of the table is as follows:

- The RMS was installed in Orbassano only and is related to all dwellings of that site. As a consequence, there is no control group related to RMS available.
- The following kinds of RUAS were available for the experimental group:
  - Heating data are available at all sub-sites. A control group of tenants who could not make use of the RUAS was available in each case.
  - Separate hot water data (in m^3) are available in Orbassano only. In that case a control group related to RUAS, but not related to RMS is available. In Spina 3 the hot water generation is included in the heating data. That's why no separate hot water data in cubic meter are available. In MOI the data provision could not be sufficiently realised due to a temporary blackout of the metering equipment (see further explanation below).
  - Cold water data are available in Spina 3 and MOI as planned.

Table 4.7.1: Basic population of pilot dwellings belonging to experimental and control group

Group Status	Orbassano (9 buildings)	Spina 3 (22 buildings)	MOI (2 buildings)	Total
Experimental group RUAS (heating)	51	169*	156	376
Experimental group RUAS (hot water)	51		(156)**	207
Experimental group RUAS (cold water)		169	156	325
Experimental group RMS	102			102
Control group RUAS (heating)	51	219*	51	321
Control group RUAS (hot water)	51		(51)**	102
Control group RUAS (cold water)		219	51	270
Dwellings with measurements	102	388	207	697

* incl. hot water generation

** could not be realised due to system blackout

The impact of the RUAS on the tenants' behaviour and awareness can be identified by applying a pre-post design with control group based on the survey results, but it is depending on the response rates.

Tenant recruitment was realised by a series of actions starting with first invitation letters to the tenants prior the release of the service in summer 2012 and continued by later face-to-face meetings introducing to the web portal and its benefits. In addition to that, ATC provided a workstation located in the main entrance hall of ATC where tenants have the possibilities to log in the portal, to find application forms asking for credentials or to find training and guidance by ATC staff of how to use the BECA services. Within the project Politecnico di Torino and ATC offered further information events on energy issues with easily understandable video material. Many tenants attended these lectures and showed interest in energy saving. In addition to that varying posters have been put in the staircases (for further details see D.5.2).

The analysis with regard to the experimental group in Torino is restricted by missing information about the dwelling-wise portal logins due to data protection issues. That's why a user/non-user comparison in addition to comparisons of experimental and control group is not possible.

There are 78 logins in total. According to the pilot site manager, the BECA service was initially welcomed by a quite numerous tenant group, even if tenants lost interest in the project duration due to a series of reasons. The most important are:

- Difficulties of portal access linked to the complex procedure to acquire the credentials: user name and password sent by post after a formal application of the tenant to ATC only;
- Low motivation to save energy due to high bills to be paid in any case. The tenants have now the possibility to monitor the consumption, but in past years the consumption generated high costs despite the innovative measurement system. So tenants lost interest because they perceive that the situation will not improve;
- System malfunctions during the BECA development that was not communicated properly to (demotivated) tenants in order to keep them connected

To solve the issue of having a small number of tenants engaged in the project and guarantee a high data quality, since recently staff of ATC and researchers of Politecnico contacted and visited many tenants' dwellings and installed data loggers. The data loggers are used to collect the inside temperatures of the dwellings in order to provide Politecnico with an instrument to verify the measured consumption figures. The immanent possibility of interacting with ATC staff and Politecnico researchers showed good results because the number of tenants asking for being connected with the portal increases.

As most tenants of the experimental group (tenants of Orbassano, MOI) received monthly paper reports and alerts in case of high consumption, the rather small number of portal users is not necessarily lowering the impact on energy and resource saving.

4.7.2 Results of consumption analysis

In Torino the consumption data analysis is related to heat energy (related to Spino 3 incl. water heating), domestic hot water and cold water. All data were available dwelling-wise on a monthly basis.

Table 4.7.2: Unit, frequency and level of measurements related to energy resp. resource

Energy /resource	Unit	Frequency of measurement	Level of measurement
Heat energy	kWh	monthly	dwelling-wise
Hot water	m^3	monthly	dwelling-wise
Cold water	m^3	monthly	dwelling-wise

Before analysing the consumption data it was necessary to carry out a data cleansing procedure. In doing so, 27% resp. 30% dwellings related to heating resp. cold water had to be excluded from analysis due to a change of tenancy in the project duration or due to incomplete data. The comparably high drop-out in the case of hot water is caused by the already mentioned partly breakdown of the metering equipment in MOI due to a cable fire which led to a long period of transmission blackout and data loss. As a consequence, only data from Orbassano could be analysed. The number of dwellings included is shown in the following table.

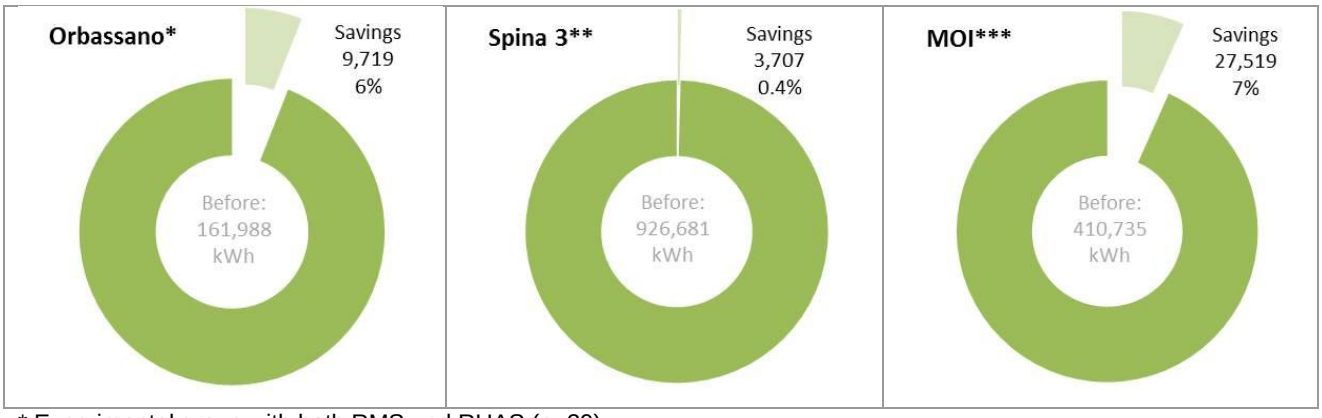
Table 4.7.3: Overview of the number of buildings and dwellings involved in the Torino pilot analysis

Site	Number of buildings involved	Total number of dwellings involved	Number of dwellings included in consumption data analyses	Data cleansing impacts (percentage of excluded dwellings)
Torino	33	Heating: 697 DHW: 309 Cold water: 595	Heating: 497 (exp. 243+contr. 254) Hot water: 82 (39+43) Cold water: 414 (219+195)	Exclusion due to change of tenancy (in total: n=40) resp. due to missing data: Heating: 200 (27%) Hot water: 227 (73%) Cold water: 181 (30%)

Global results

The calculation of the global savings following a pre-post comparison led to the results shown in the both following figures. Due to the very different characteristics of the three pilot sites related to heating, the global heat energy savings had to be calculated separately for each sub-site: The experimental group of MOI with the possibility of RUAS use achieved the highest savings of 7%. In Orbassano, where a RUAS as well as a RMS is in operation, 6% savings could be achieved. In Spina 3, where tenants could make use of a RUAS providing combined feedback of heating and hot water generation, the consumption stayed more or less unchanged (small savings of 0.4%).

Figure 4.7.2: Overview of global results of the experimental group in Torino (related to heating)



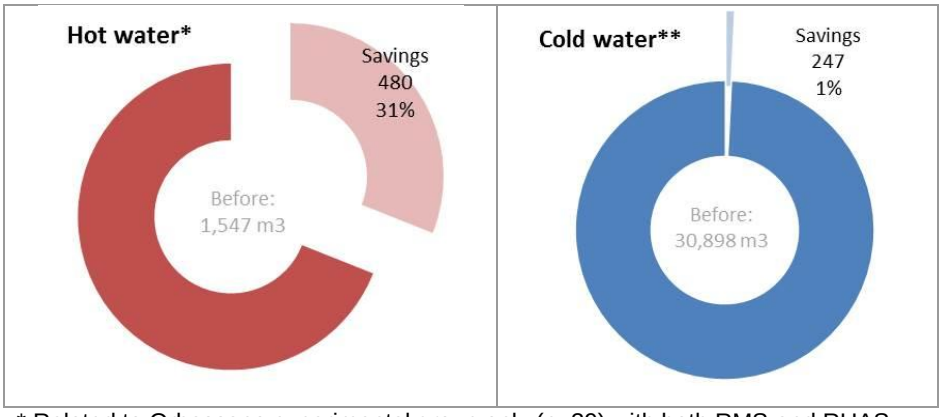
* Experimental group with both RMS und RUAS (n=39)

** Experimental group with RUAS only, hot water generation included (n=149)

*** Experimental group with RUAS only (n=55)

Related to domestic hot water, the Orbassano tenants achieved enormous savings of 31%. In the case of cold water, which is part of the RUAS in Spina 3 and MOI, the achieved savings of 1% are even smaller.

Figure 4.7.3: Overview of global results of the experimental group in Torino (related to water)



* Related to Orbassano experimental group only (n=39) with both RMS and RUAS

** Without Orbassano, where cold water was not part of the RUAS (included: n=219)

Compared to the saving target of in total 6 up to 10% (see D5.2) it becomes obvious that the hot water savings are far above expectations. In the case of heat energy, two of the three pilot sites met the target. Related to cold water the saving target could not be fully achieved. However, the detailed analysis below will show that this result can also be interpreted as success because the experimental tenants living there act already very water-saving. That restricts their possibilities to save even more water are limited.

The following table gives an overview of the CO_2- and cost savings related to the above diagrammed global energy/resource savings of the experimental group.

Table 4.7.4: Overview of global CO_2- and cost savings of the experimental group in Torino

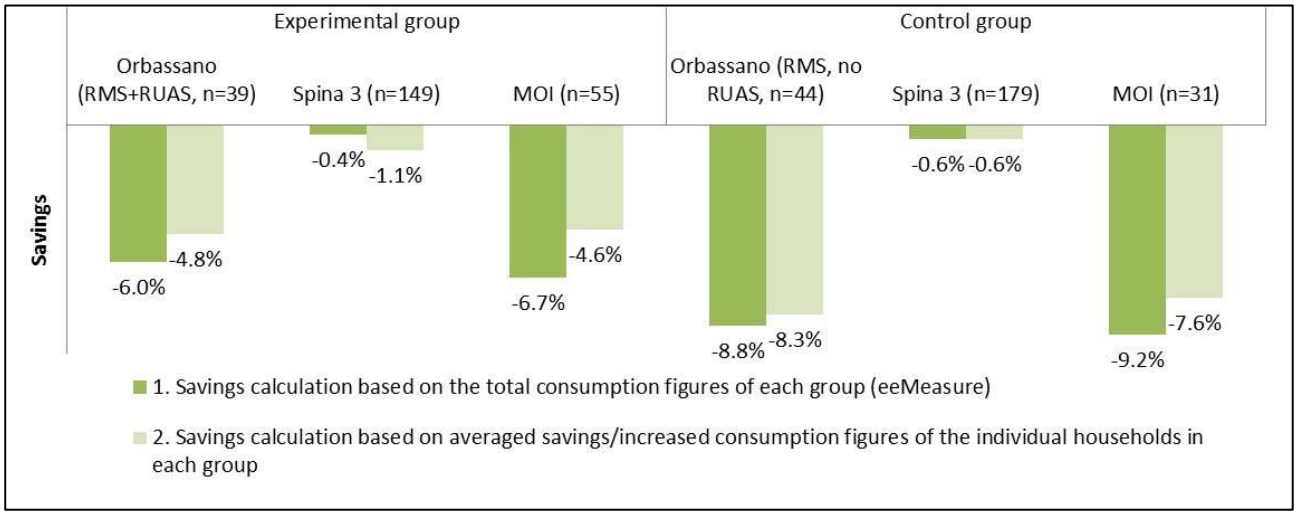
Energy /resource	CO_2-Savings		Cost savings	
	Factor	Savings in kg CO_2	Price	Savings in €
Heat energy (Gas)	0.216 kg CO_2/kWh	2,900	0.085 €/kWh	1,141
Heat energy (DH)*	0.278 kg CO_2/kWh	7,650	1.135 €/kWh	31,234
Hot water	n/a	n/a	6.80 €/m^3	3,264
Cold water	n/a	n/a	1.40 €/m^3	346
Total		**10,550**		**35,985**

* District heating is available in MOI

Heating

The following figure shows that in Orbassano and MOI both comparison groups achieved significant heat energy savings whereas in Spina 3 the consumption was more or less unchanged. The divergences in the presented figures are again caused by the different calculation models.

Figure 4.7.4: Percentage change in heat energy consumption related to RUAS experimental and control group at each pilot sub-site in Torino



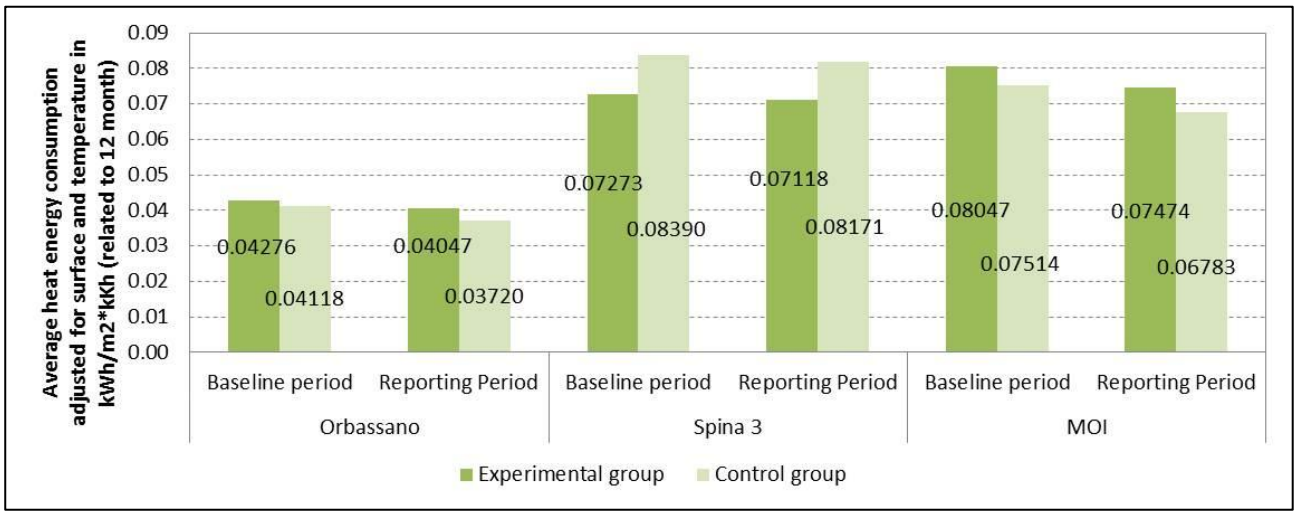
Possible explanations for these results are as follows:

- In Orbassano the positive impact of the RMS became obvious which was in operation in the dwellings of the RUAS control group as well. The installation of the RMS allowed to direct attention to system malfunctions which could be solved more rapidly than before, and to enable further improvements by adapterm.
- In MOI live a lot of tenants with health and social problems. The housing provider reported about a high quantity of rent arrears. Those tenants receive financial support for heat energy and rents. In addition to that, the following figure shows that the average baseline heating consumption in MOI is nearly twice as high as in Orbassano. That leads to a higher financial burden which is additionally enforced by the higher price for district heating compared to gas (see cost table above). So it can be assumed that people living in MOI have a high interest in reducing their living expenses. That could be the reason for the consumption reduction also in the control group in MOI.

- The comparably small saving result in Spina 3 is caused by the nearly equal number of households with savings and households with increased consumption whereas the average savings resp. average consumption increase is at similar level. However, also in Spina 3 more than half of the tenant households achieved savings (see table below).

A further in-depth study is not possible due to missing information of actual service use. But it can be assumed that tenants with savings were more often beneficiaries of the energy saving campaign of the project.

Figure 4.7.5: Average adjusted heat energy consumption in kWh/m^2*kKh related to experimental and control group at each pilot sub-site in Torino



The following table can show, that – independently from the group status – always more tenant households achieved savings than consumption increase. Tenants with savings reduced their heat energy consumption by 14 up to 23%.

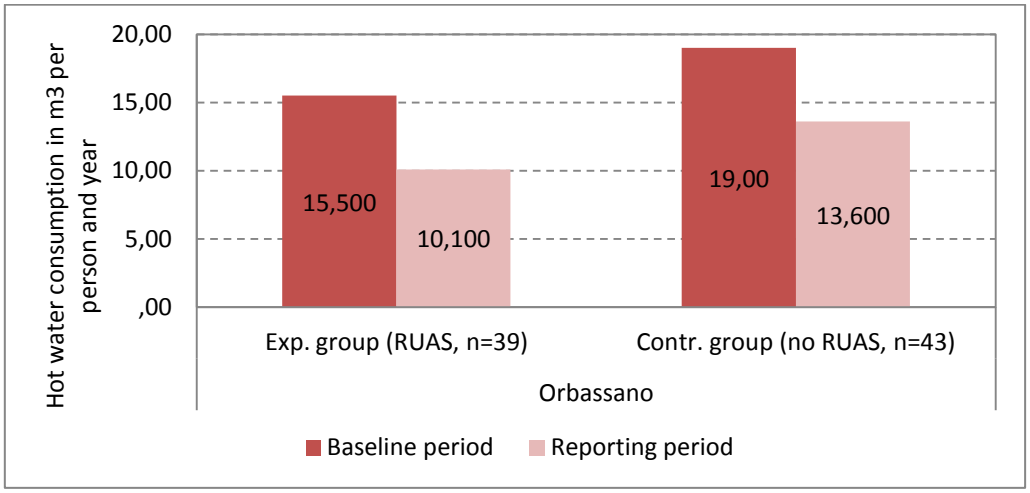
Table 4.7.5: Percentage of dwellings with heat energy savings/increased consumption and correspondent average figures related to experimental and control group

	Experimental group			Control group		
	Orbassano	Spina 3	MOI	Orbassano	Spina 3	MOI
Absolute number and percentage of dwellings with savings	22 (56%)	79 (53%)	37 (67%)	28 (64%)	98 (55%)	19 (61%)
Average savings of dwellings with savings	-23.1	-16.6	-14.4	-23.1	-15.0	-22.3
Absolute number and percentage of dwellings with increased consumption	17 (44%)	70 (47%)	18 (33%)	16 (36%)	81 (45%)	12 (39%)
Average increased consumption of dwellings with increased consumption	+18.7	+16.4	+15.7	+17.6	+16.8	+15.8

Hot water

Both calculation approaches assessed that the RMS had a big impact on the reduction of the hot water consumption. As the following figure shows, both comparison groups achieved immense savings. In addition to that, the RUAS, which was available for the experimental group of Orbassano tenants only, seems to have a positive impact too.

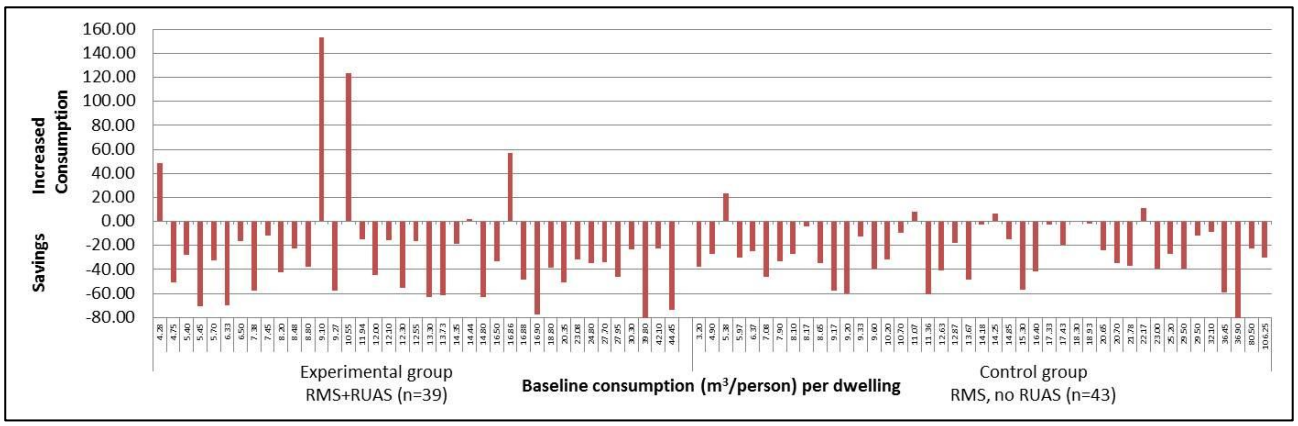
Figure 4.7.6: Percentage change in hot water consumption related to RUAS experimental and control group



These enormous savings are very likely due to a strong motivation of the tenants[103] to save money. However, a modification of the billing system (e.g. the replacement of an all-inclusive rent by a billing based on actual individual consumption, as Örebro did) did not occur.

The divergence between both calculation approaches has again a solely mathematical explanation of different weights individual household data carry in one or another direction. In the present case, that is only relevant for the experimental group. There few households with realistic low absolute baseline consumption figures had a comparably large increase in relative figures when consumption turned into normal. That led to the comparably smaller averaged savings results when using calculation model 2.

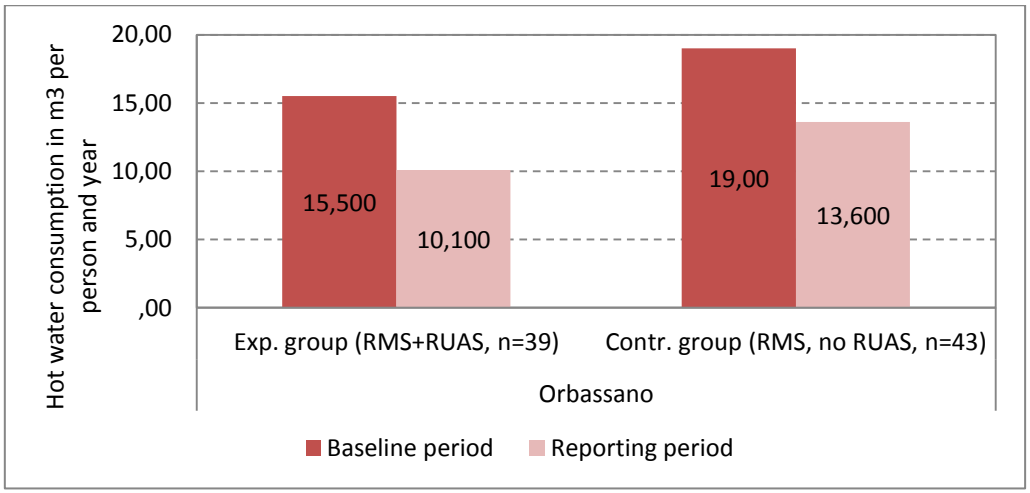
Figure 4.7.7: Savings resp. increased consumption per household (in %) related to baseline hot water consumption (in m^3 per person) in Orbassano



[103] The pilot site manager reported on a large number of elderly resp. retired people with probably low pensions.

The following figure shows that in both groups the hot water consumption could be decreased by 5.4 m^3 per person and year on average. However, the tenants of the experimental group started already with a lower consumption per capita than the control group which generally illustrate their already more conscious consumption behaviour as well as their more restricted possibilities to save even more hot water.

Figure 4.7.8: Average hot water consumption in m^3 per person

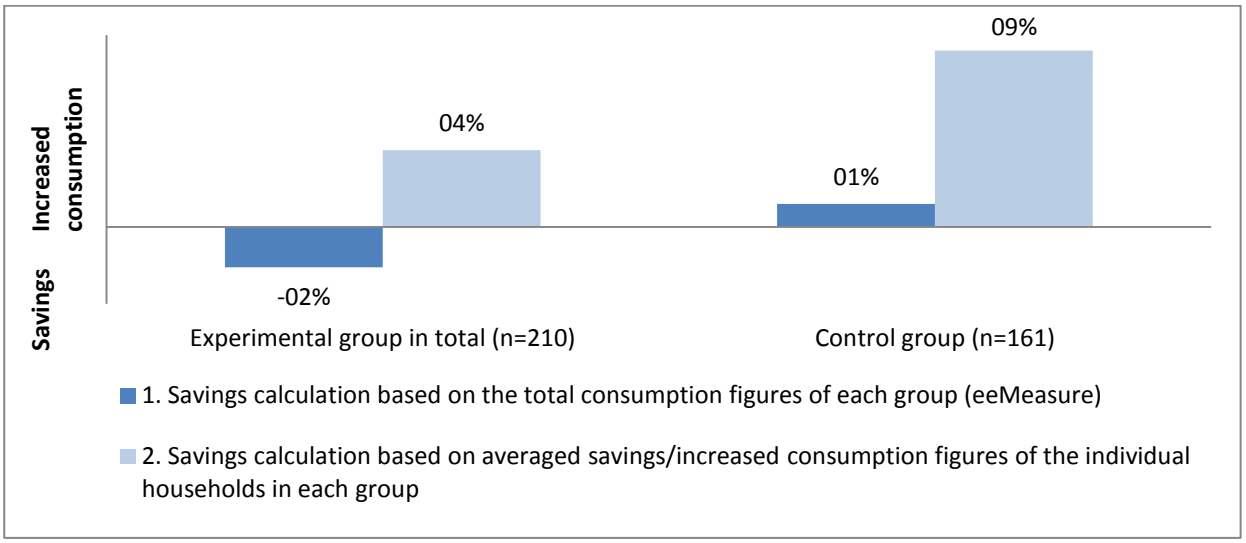


87% of the experimental group (n=34) and 88% of the control group (n=38) achieved average savings of 43% resp. 32%. In each case only five households had an increased consumption which can be interpreted as a success of the management system.

Cold water

In deviation to the sample of the global savings calculation above, the following used sample size is a bit smaller due to partly missing information about the number of persons in the household which is an important adjustment parameter in the case of water consumption.[104]

Figure 4.7.9: Percentage change in cold water consumption related to RUAS experimental and control group

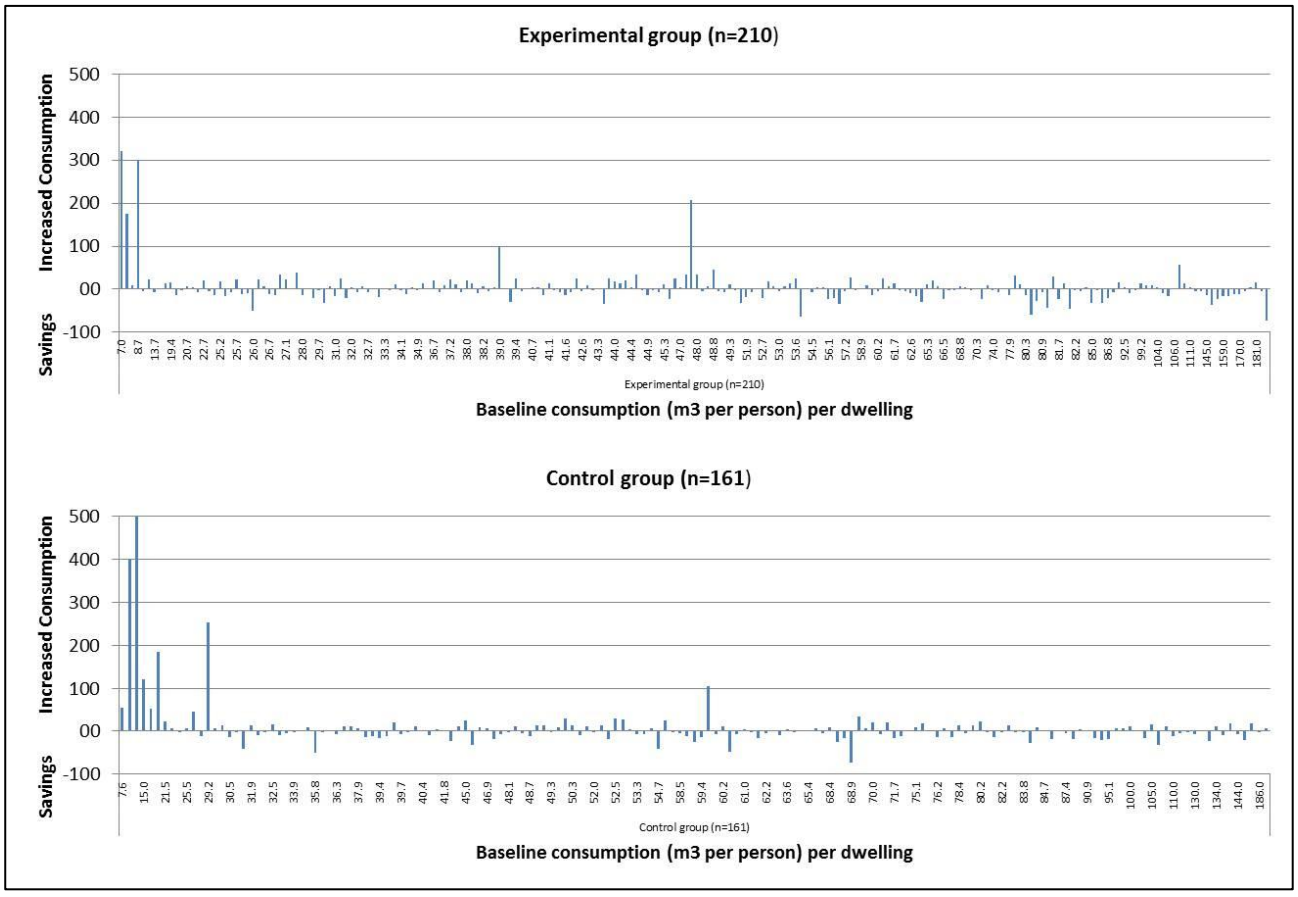


[104] Experimental group: minus 9 dwellings; control group: minus 34 dwellings

Whatever the used calculation approach is, the experimental group achieved better results than the control group, whereas these differences are statistically not significant.

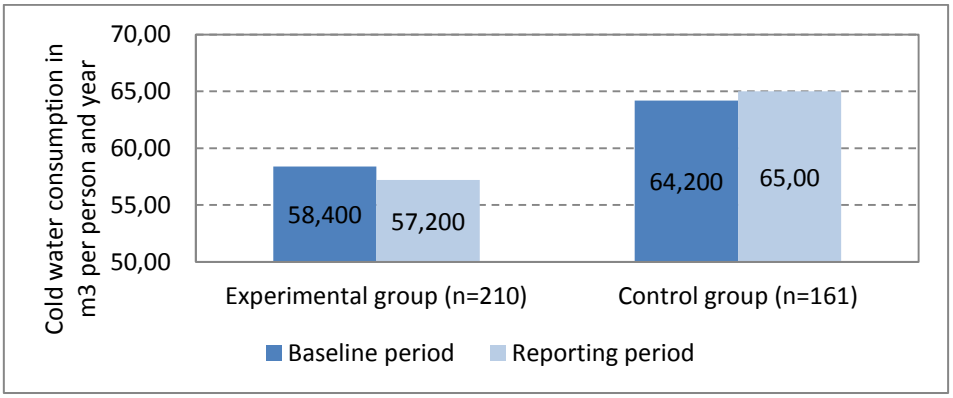
The divergence of the above presented figures is again due to the different weights individual household data carry in both calculation models. In the present case, that is especially relevant for the control group, but to a lesser extent also for the experimental group. Some households with realistic low absolute baseline consumption figures had a comparably large increase in relative figures when consumption turned into normal. That led to the consumption increase when using calculation model 2. In addition to that, one half of the sample achieved savings, the other have had a consumption increase (see table 4.7.6).

Figure 4.7.10: Savings resp. increased consumption per household (in %) related to baseline cold water consumption (in m^3 per person)



The tenants of the experimental group had already 9% lower baseline cold water consumption per person on average than the tenants of the control group. That suggests that their possibilities to save even more water are comparably limited. Against that background the achieved savings of 2% can be assessed as success.

Figure 4.7.11: Average cold water consumption in m³ per person



As the following table shows, approximately half of the tenant households of both comparison groups achieved savings at a level of minus 13-14%. The other half in each case increased their water consumption – the control group on a significant higher level than the experimental group.

Table 4.7.6: Percentage of dwellings with cold water savings/increased consumption and correspondent average figures related to RUAS experimental and control group[105]

	Exp. group	Contr. group
Absolute number and percentage of dwellings with savings	107 (51%)	80 (50%)
Average savings of dwellings with savings	-14.3	-13.1
Absolute number and percentage of dwellings with increased consumption	101 (48%)	80 (50%)
Average increased consumption of dwellings with increased consumption	+23.4	+31.5

4.7.3 Results of survey analysis

Results of mid-term survey

General Report

The mid-term survey was conducted with two persons of the heating management.

Both interviewees agree with the simplicity of the interface to be delivered to the tenants – it is crucial to provide easy information to read. Positive comments were related to the graphics. It was noticed that after a rising interest at the beginning tenants lost interest in the portal which might be caused by the absence of alerts at present. From a software development point of view BECA represents a good pilot for interaction between tenants and ATC structure. The necessary improvements of the tenant portal concern the possibility to visualize hot water consumption in a more clear way. The graphic appearance of the portal both interviewees assessed as good. The same applies to the easy accessing and the information given. The interesting aspect of these interviews is the good response regarding energy saving tips and information given by the portal. The two interviewees are interested in learning how to act responsibly towards energy efficiency and suggested to extend the project approach to other projects or at least to add the saving tips to the package given to the tenants when they enter a new house. The report was positive with regard to the appearance of the portal, the accessibility to the service and the merit of the service concerning to efficient maintenance.

[105] Difference to 100% is due to 3 households with no change in consumption figures (exp. 2, contr. 1)

Specific report:

The Heating Management introduced the BECA portal on several occasions to involved and not involved colleagues and both applied energy tips at home. The IT engineer talked to the key people in the company in order to evolve BECA in the ATC tenant's portal. Since he has been involved in BECA, he changed his attitude to energy consumption. When reading he started thinking about energy saving and since then he followed almost all tips included the ones related to electricity, gas and the way to use appliances.

ATC specific questions:

Regarding training the two interviewees are confident in their capability and think they would be able to train other colleagues especially concerning to how to interpret consumption data. The energy manager suggests that training should be done by an energy engineer together with a software engineer. The both technical staff agrees that alerts will be crucial in order to resolve promptly any issue on site. The IT department find that the portal is so easily designed that there won't be any problem to train people. The most important thing is not how to access the portal but how to read and interpret the content. The main use of the portal should be for the engineers to run maintenance, tenants can change their behaviour by using the portal, but they will definitely think the portal is useless if it does not improve maintenance performances. The good thing of BECA beyond the portal is the fact that it is a project with lots of countries involved to provide a service, and when ATC will have developed the full tenant portal it will be a real novelty. Both project architect and project manager agree with the difficulties to extend training to other departments when technology and innovation are not supported. Both are concerning about the possibility of non-technical staff to advise tenants in the wrong way regarding energy consumption (this related to call centre). Both interviewees are optimistic about an efficient use of the portal by the maintenance staff. The energy manager is hopeful, that portal user would be useful to run maintenance and problem solving quicker. This is the foreseen development of BECA. At present the in-house company did not benefit from the use of the portal, but this is a future objective. He saw already other tools similar to the BECA portal in the market. The innovation of the BECA project is the tenant's involvement that is not contemplated in other services of the same type. The possibility to compare the consumption of different dwellings would help to address tenants more efficiently regarding energy saving.

Data basis and profile of respondents at baseline and final survey

The response rates of the baseline and the final survey are satisfactory considering that Torino represents a big pilot site. At baseline stage 94 tenants of the experimental group (for RUAS) and 62 tenants of the control group (for RUAS) responded to the survey. This represents a response rate of 25% resp. 20%. At the final stage the response rates are similar (22% for experimental group and 23% for control group).

The surveys were realised in several rounds in order to reach as many tenants as possible. First the survey was conducted face-to-face with persons who have been reached at home. Secondly, tenants were called by telephone. Thirdly, interviews were carried out in tenant meetings.

The following table shows on which basis the following analyses can be done. Pre-post comparisons are restricted to tenants participated in both surveys. These are 14 tenants of the RUAS control group and 31 tenants of the RUAS experimental group. Due to these rather small samples mean comparisons are restricted to the experimental group.

Table 4.7.7: Number of respondents per survey stage

Survey stages	Evaluation Group		Total
	Control Group (RUAS)	Experimental Group (RUAS)	
Only baseline survey	48	63	111
Only final survey	61	51	112

baseline and final survey	14	31	45
Total	123	145	268

The profile of the respondents is shown in table 4.7.8. Most of the characteristics show similar distributions for both groups and no major differences for the two subsamples (at least final participation; baseline and final participation). Nearly all tenants of both groups are born in Italy, the average age ranges between 58 and 62 years, whereas – based on the tenants participated in both survey stages – the tenants of the experimental group are slightly older. The highest level of education is a primary/secondary school leaving qualification of the majority of control group and experimental group tenants, followed by a secondary school leaving qualification. The median household size is two persons in each group and subsample.

Table 4.7.8: Profile of respondents in relation of survey participation

Characteristics (based on answers at the final survey)		Final		Baseline and final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
Sex	Male	29 (41%)	44 (57%)	2 (14%)	14 (48%)
	Female	41 (59%)	33 (43%)	12 (86%)	15 (52%)
Country of birth	Italy	70 (100%)	75 (99%)	13 (100%)	25 (96%)
	Other	0 (0%)	1 (1%)	0 (0%)	1 (4%)
Age	Mean	58	58	58	62
	Median	58	59	58	61
Level of education**	No school leaving qualification	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Primary/secondary school leaving qualification	6 (60%	9 (69%)	1 (50%)	4 (67%)
	Secondary school leaving qualification	4 (40%)	3 (23%)	1 (50%)	2 (33%)
	University entrance qualification	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	University/university of applied science degree	0 (0%)	1 (8%)	0 (0%)	0 (0%)
Size of household	Median (persons)	2	2	2	2
Absence of all household members at normal week day	0-2 hours	13 (22%)	31 (48%)	3 (27%)	12 (52%)
	3-5 hours	44 (75%)	28 (43%)	8 (73%)	8 (35%)
	6-8 hours	2 (3%)	6 (9%)	0 (0%)	3 (13%)
	More than 8 hours	0	0	0	0

Characteristics (based on answers at the final survey)		Final		Baseline and final	
		Control Group	Exp. Group (RUAS)	Control Group	Exp. Group (RUAS)
		(0%)	(0%)	(0%)	

** Missing values reduce sample for participation at baseline and final stage; n=8).

Differences between experimental group and control group can be found related to the sex of the respondents and the duration of absence of all household members from their homes at a normal weekday. The majority of respondents in the control group are women regarding tenants who participated at least in the final survey (59%). Vice versa, in the experimental group there are 43% female respondents. Among the tenants who participated in both survey stages women are also overrepresented in the control group (86%) whereas the sex ratio of the experimental group is uniformly distributed (52% women). With respect to the absence of all household members from home, it can be seen that the time period of absence is somewhat longer in the control group than in the experimental group. This is true for both subsamples. As the sample size is very low regarding tenants who participated in both surveys, these results should be treated carefully.

RUAS use and motivation of tenants

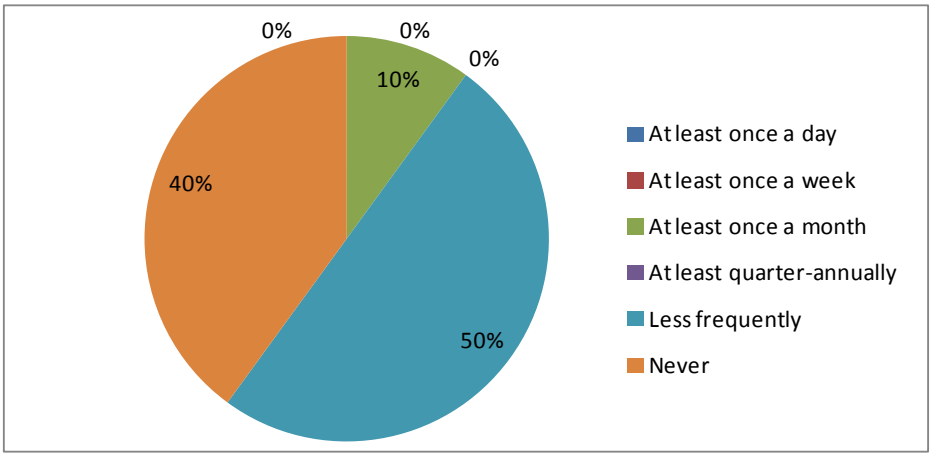
Among the tenants of the experimental group who participated in the final survey only 4% state that they already heard about the tenant portal offered by the housing provider (10 tenants). 71 tenants (88%) denied that. This result is somewhat striking, but the mid-term interviewees means that the tenants didn't remember it at the moment they have been asked the question. However, this shows a low interest in a web portal application. But it should be considered that ATC has very complicated rules to be followed to produce passwords and usernames for tenants. They include several application forms to be filled in by tenants that must be returned in paper (faxes or post). This represents rather high barriers for the tenants, especially for the mainly elderly tenants of the sites. The pilot site manager also pointed out that the level of unpaid bills is very high and therefore tenants could be scared by an energy saving measure. Against this background the low motivation of tenants for using the portal is more understandable.[106]

As the following figure shows, one of the ten tenants logs in the tenant portal at least once a month, five tenants log in less frequently than quarter-annually and four tenants never logged in. This means that only one tenant can be categorised as active user.

With respect to the low number of active users, it has to be considered that this result only bases on tenants who have participated in the survey and does not show the actual number of users (as already mentioned in section 2.2.2). Additionally, tenants also received paper reports and therefore could benefit from the services even if they not make use of the web portal. However, as questions about the usefulness of the tenant portal were addressed to active users only, an analysis of those questions is not very useful.

[106] For further information also see section 4.7.1.

Figure 4.7.12: Frequency of portal use
(n=10; respondents of final survey)



Survey Question: How often do you log in the tenant portal usually?

Before starting the RUAS services, the motivation to save energy consists predominantly in saving money and protecting the environment equally. This is true for the control group (69%) and the experimental group (57%). Solely to save money ranges at second position with 31% agreement in the control group and 20% in the experimental group. In the experimental group another 20% stated that saving money is more motivating than protecting the environment.

At the final stage it can be observed that tenants who were motivated more by the money saving aspect at baseline stage now are also motivated by both aspects. In the experimental group all tenants feel motivated by both aspects equally, in the control group the proportion raised up to 90%. The remaining two tenants still are more motivated by the money saving aspect. As there are no differences between control group and experimental group obvious, these results are not induced by the RUAS services. Instead, to protect the environment seem to be a trend that generally became stronger during the time of service operation.

Reasons for using the tenant portal

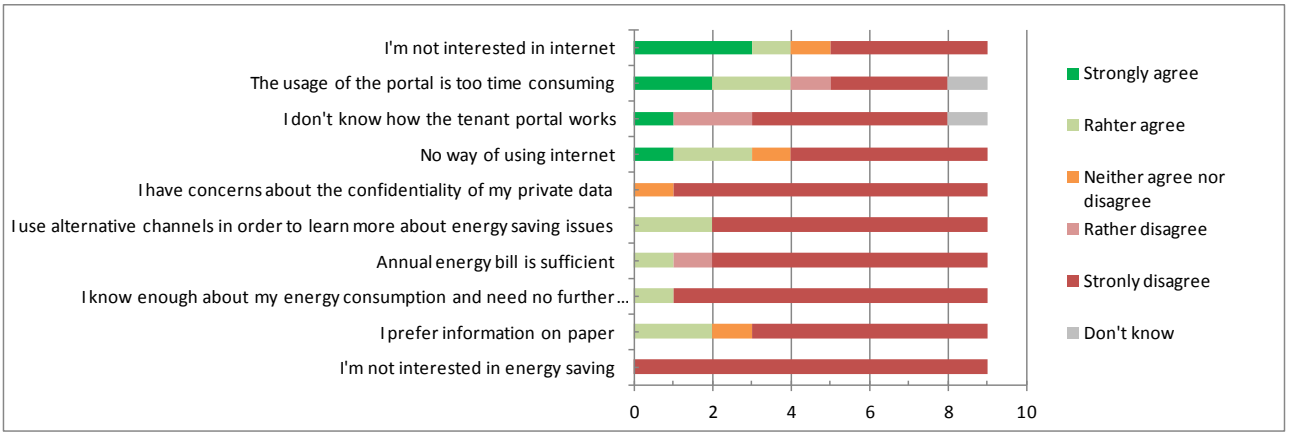
The tenant who is actively using the tenant portal was asked about the reasons for using it. The tenant strongly agrees to all four reasons that have been given in the survey. So, he/she wants to know more about the energy consumption and would like to reduce it and he/she wants to keep an eye on the energy costs and would like to reduce them.

Reasons for not using the tenant portal

The nine tenants who do not belong to the active users, but know the tenant portal have been asked about their reasons for not (regularly) using the tenant portal. As the following figure shows, none of the asked reasons can clearly be identified as main reason. At the same time the tenants did not specify other reasons.

However, the reasons seem to be related to the medium internet and to time investments. Four tenants agree to be not interested in internet. Three tenants have no way of using it. Four tenants assess the usage of the portal as too time-consuming. Two tenants use alternative channels in order to learn more about energy saving issues. Two tenants prefer paper information. It also becomes obvious that a lack of interest regarding the issue of saving energy is not a reason for non-usage of the tenant portal.

Figure 4.7.13: Reasons for not using the tenant portal
(n=9; non-active users)

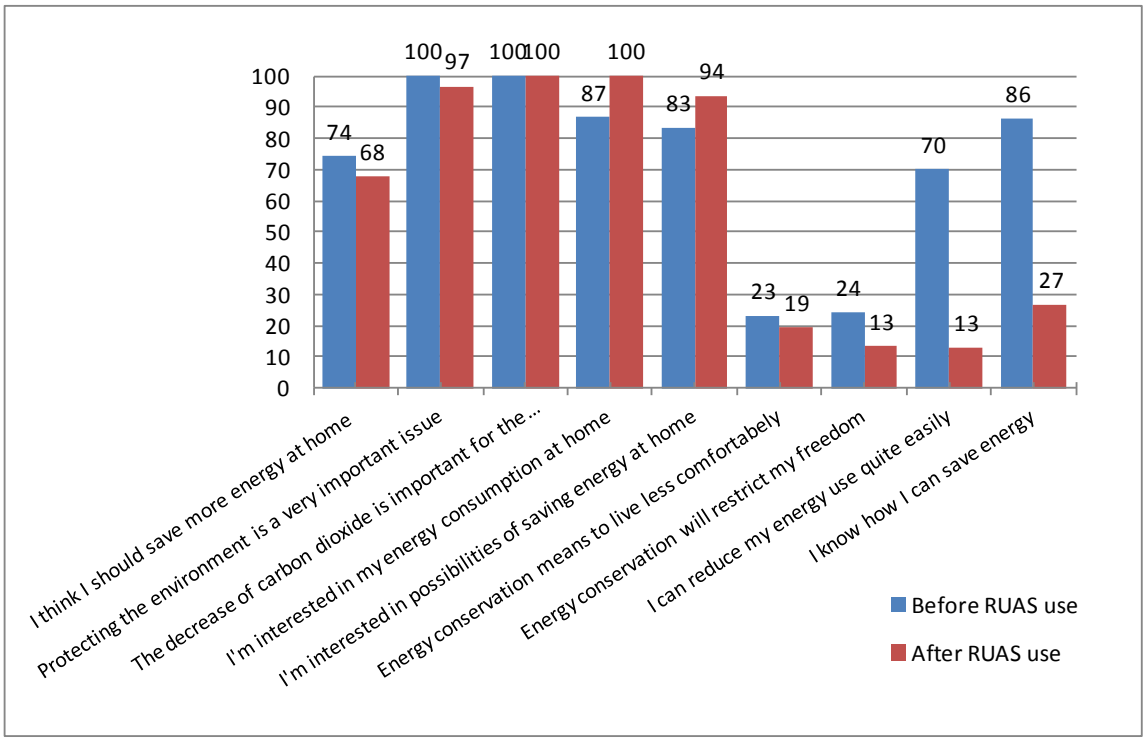


Survey question: There are different reasons for not using the tenant portal. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know

Impact on ecological awareness

Figure 4.7.14 mainly shows high levels of ecological awareness already at baseline stage. This is especially true for the general attitudes with proportions of agreement up to 100%. More than 80% of the tenants are interested in their energy consumption at home and in possibilities to save energy and think to know how they can save energy. Nearly three quarters think that they should save energy at home and that they can easily reduce their energy consumption. In addition to that, very few tenants feel restricted by energy conservation with respect to comfort and freedom.

Figure 4.7.14: Ecological awareness of experimental group tenants before and after RUAS use
(n=29-31 due to missing values); percentages for answer categories "strongly agree and rather agree")

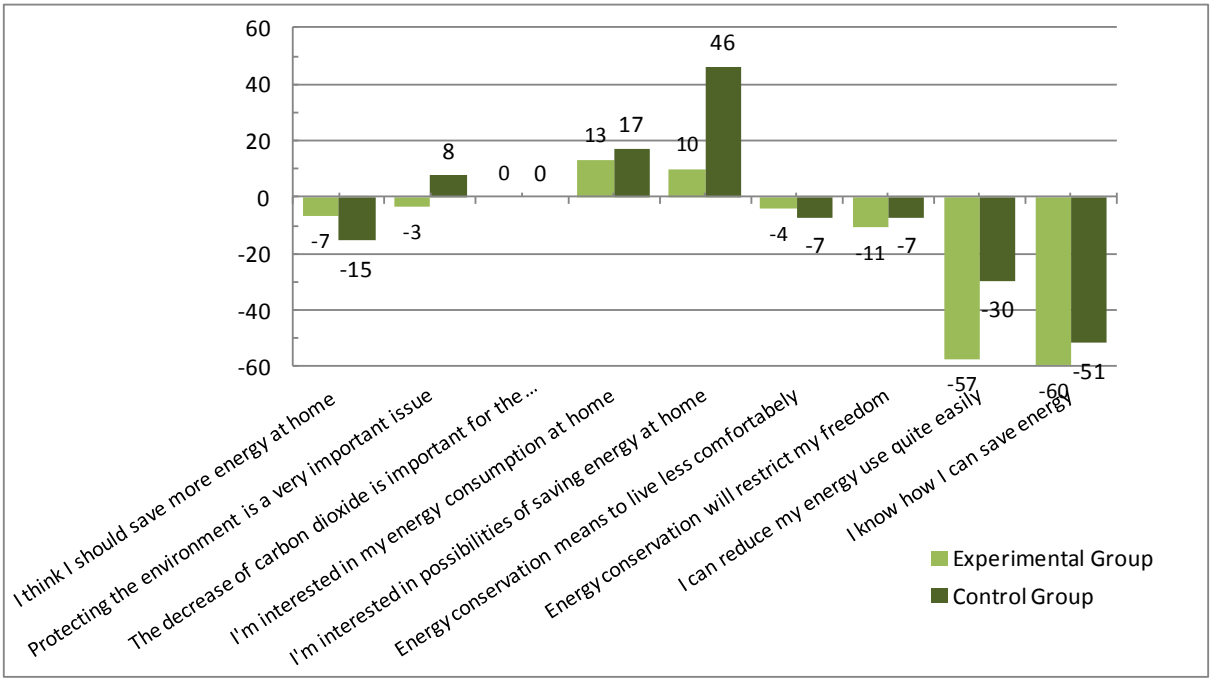


Question: There are different opinions about the need and the possibilities to protect the environment and to save energy. To what extent do you agree or disagree with the following statements?
Answer categories: I strongly agree, I rather agree, I neither agree nor disagree, I rather disagree, don't know.

After the use of the RUAS, the level of ecological awareness increased or remained at the same high level (agreement of 100%) related to items addressing general convictions and personal interest. The biggest increases can be found for the interest in energy consumption at home and in possibilities for saving energy at home. At the same time feelings about restrictions by energy conservation diminish once more to 19% (restriction of comfort) and 13% (restriction of freedom). On the other hand, after the use of RUAS, fewer tenants than before think that they should save more energy at home, that they can reduce their energy use quite easily and that they know how to save energy.

The following figure shows that there are similar trends in the control group although with varying degrees of changes. This shows that there seem to be some general trends besides the RUAS that influenced ecological issues. However, due to the rather small sample size of the control group, the degrees of differences should not be over-interpreted.[107]

Figure 4.7.15: Changes of ecological awareness of experimental group and control group tenants
(n=29-31 for experimental group and 12-13 for control group due to missing values[108]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)



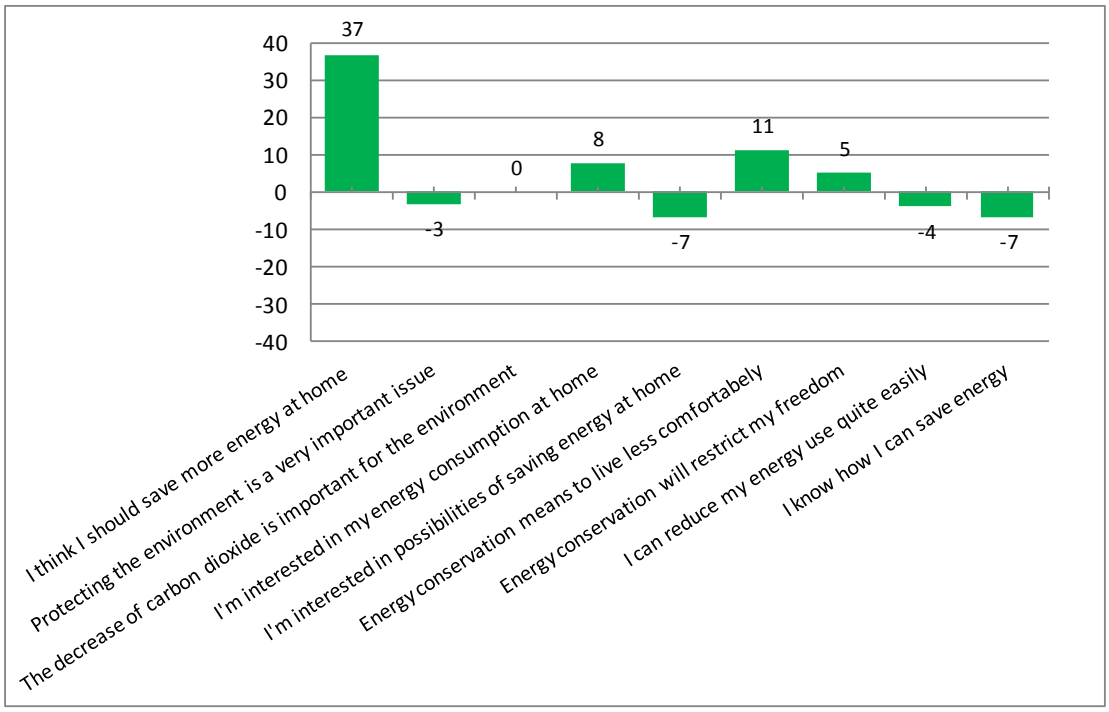
Looking at differences in both groups at final stage it becomes obvious that such differences for most of the items are smaller than 10%-points. Bigger differences can be found for the opinion that energy conservation means to live less comfortably and especially for the subjective energy saving norm that tenants should save more energy at home. This last-mentioned item shows best a positive influence of the RUAS when taking into account the initial situation at baseline stage. This is true because the services helped to improve the conviction that tenants should save energy at home at a high level in a way that the difference between both groups increased in the course time. In other words this means that at baseline stage already more tenants of the experimental group than of the control group thought that they should save energy, but this difference increased once more at final stage. This effect cannot be found for further items. In contrast, for some

[107] Based on mean comparisons, the positive trends that can be found in the experimental group are not statistically significant. Within the control group, mean comparisons are not useful due to the small sample size.

[108] Answer categories „not applicable” and “don’t know” were coded as missing.

statements the differences to the disadvantage of the experimental group increased. This is especially true for the interest in the possibilities of saving energy at home and the conviction that tenants can reduce their energy use quite easily.

Figure 4.7.16: Differences between experimental group and control group at final stage
(n=30-31 for experimental group and 12-13 for control group due to missings[109]; percentage point differences for answer categories "strongly agree and rather agree")



As on the basis of the final survey, only one tenant could be identified as active user, the question about the knowledge and the relevance of energy saving issues resulting from the RUAS use was only asked to this tenant.

The tenant stated that he/she thinks to know more about his/her energy consumption due to the tenant portal and that he/she kept an eye on his/her energy consumption due to the portal.

In summary, there seems to be no meaningful influence of the RUAS on the ecological awareness of tenants besides of an increased individual energy saving norm. Further positive trends that have been found in the experimental group cannot be interpreted as mainly caused by the RUAS as they also appear in the control group. This small influence can be explained by the low number of portal users that was planned as the main feature of the RUAS. The potential of the tenant portal to influence the tenants' ecological awareness is only confirmed by the increased knowledge and relevance of the energy consumption at home that was found for the active user of the portal.

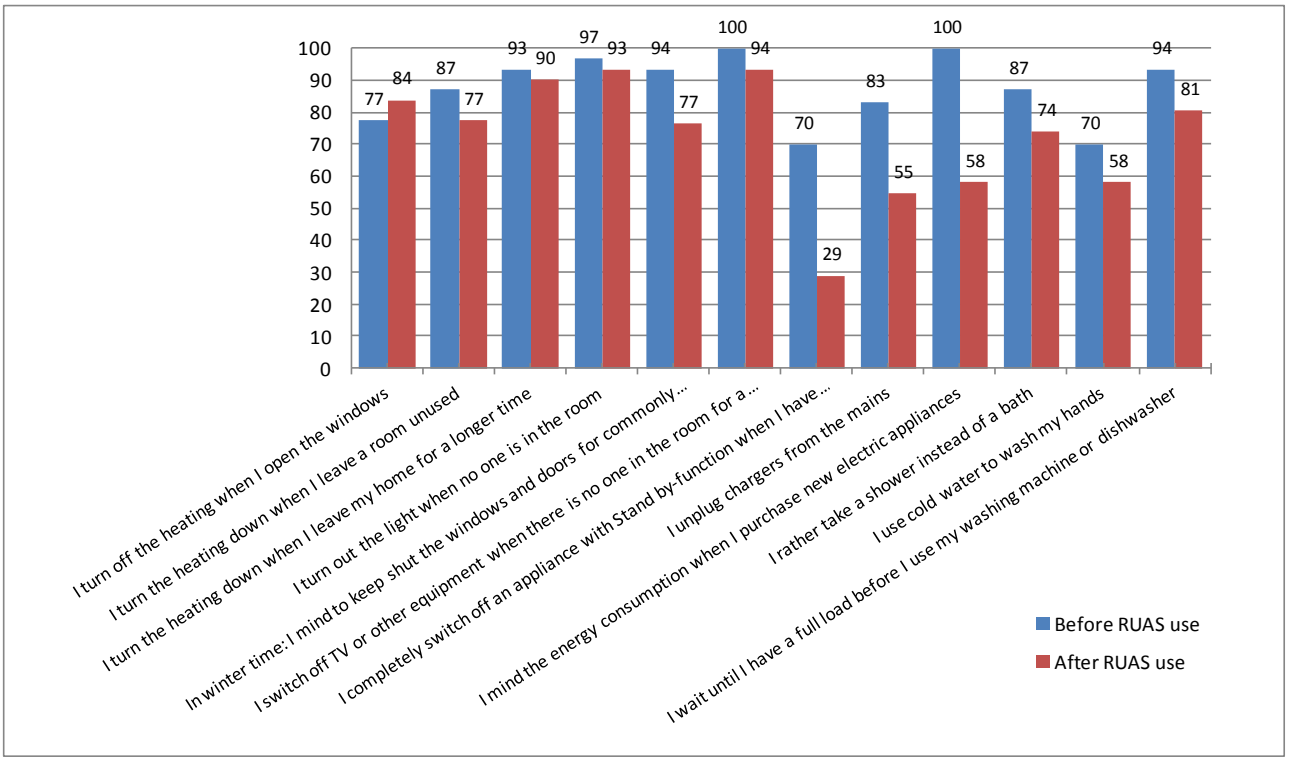
[109] Answer categories „not applicable" and "don't know" were coded as missing.

Impact on ecological behaviour

The following figure shows a very high level of ecological behaviour already at baseline stage. More than three quarters of the tenants behave in an ecological manner with respect to almost all items. To completely switch off TV when there is nobody in the room and to use cold water for washing hands represent the items with the lowest values. However, there are still 70% of the tenants who behave in the desired way.

At the final stage this high level is generally remaining rather constantly with only small decreases of some actions. Comparably higher decreases can be found related to actions regarding resources that are not part of the RUAS (electricity consumption). This is a positive hint that the RUAS may have contributed to hold the ecological behaviour at a high level (which is quite difficult if behaviour has not become a routine yet).

Figure 4.7.17: Ecological behaviour of experimental group tenants before and after the use of RUAS
(n=30-31 for due to missings[110]; percentages for answer categories "strongly agree and rather agree")

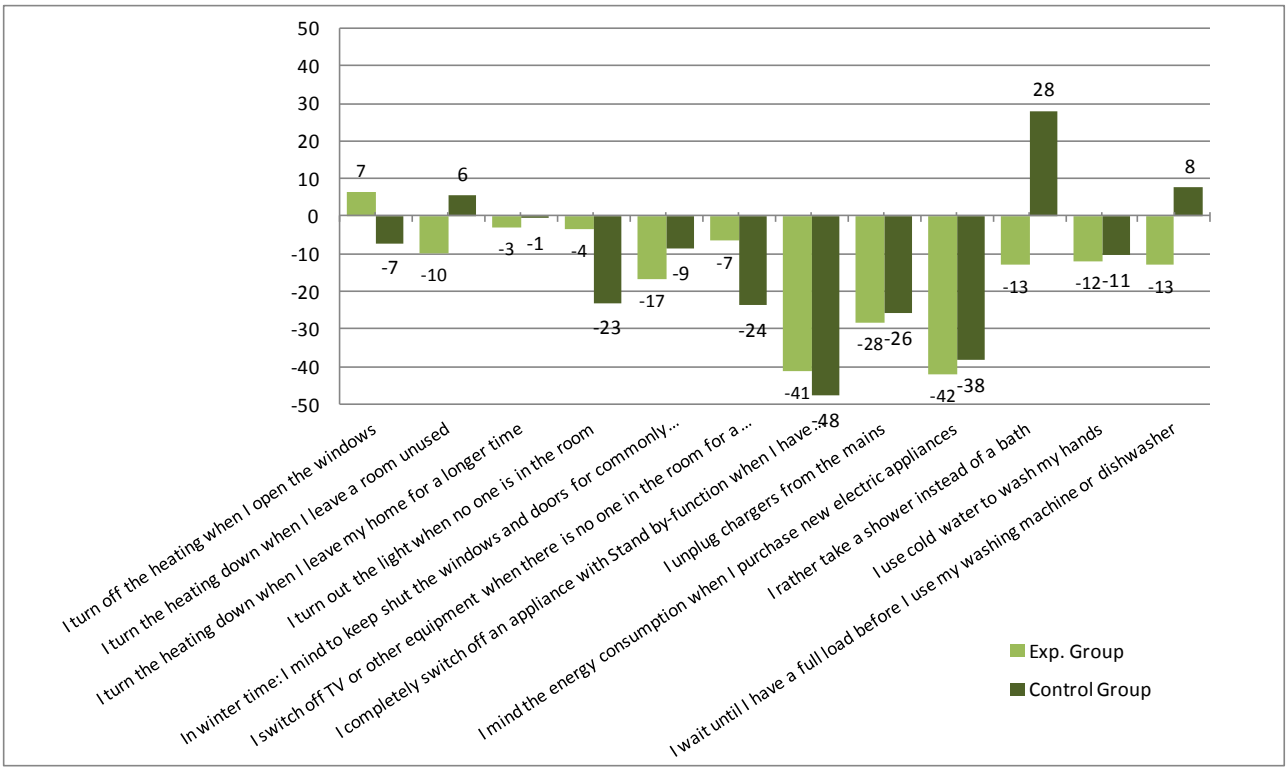


As already seen with regard to the development of the ecological awareness, behaviour developments show mostly similar trends in both groups. The fact that the trends are mainly negative is resulting from the initial situation at baseline stage which shows high levels of ecological behaviour for both groups. As the development of the ecological awareness is quite similar, it can be assumed that the issue of saving energy was very popular at baseline stage (autumn 2012) and generally has lost some attention until the final stage (autumn 2013). This general trend seems to be stronger than the influences of the RUAS. However, the experimental group tenants more often turn off the heating when opening windows at final stage whereas for the control group an opposite trend can be found. This can be interpreted as an influence of the tenant portal.[111]

[110] Answer categories „not applicable" and "don't know" were coded as missing.

[111] As this trend in the experimental group is not statistically significant on the basis of a mean comparison, it cannot be excluded that other factors also have an influence.

Figure 4.7.18: Changes of ecological behaviour of experimental group and control group tenants
(n=30-31 for experimental group and 12-13 for control group due to missing values[112]; pre-post comparisons; percentage point differences for answer categories “strongly agree and rather agree”)



At final stage the tenants of the experimental group show much more better ecological behaviour for some items than the control group. For further items mainly related to heat energy the differences between both groups are very small (max. 2%-points). Only two items show that in the experimental group fewer tenants behave in a pro-ecological manner than tenants of the control group do. But when taking into account the initial situation of both groups, the – compared to the control group more seldom optimal – behaviour of the experimental group at final stage regarding turning off the heating when opening windows and completely switching off appliances with stand by-function with can also be interpreted as positive result. This is true because the difference between both groups declined during the use of the RUAS. So the RUAS helped reducing the negative trend that generally seems to exist. On the contrary, the experimental group tenants have somewhat lost their earlier advantage with respect to unplug chargers from the mains, mind the energy consumption when purchasing new appliances and use cold water for washing hands.

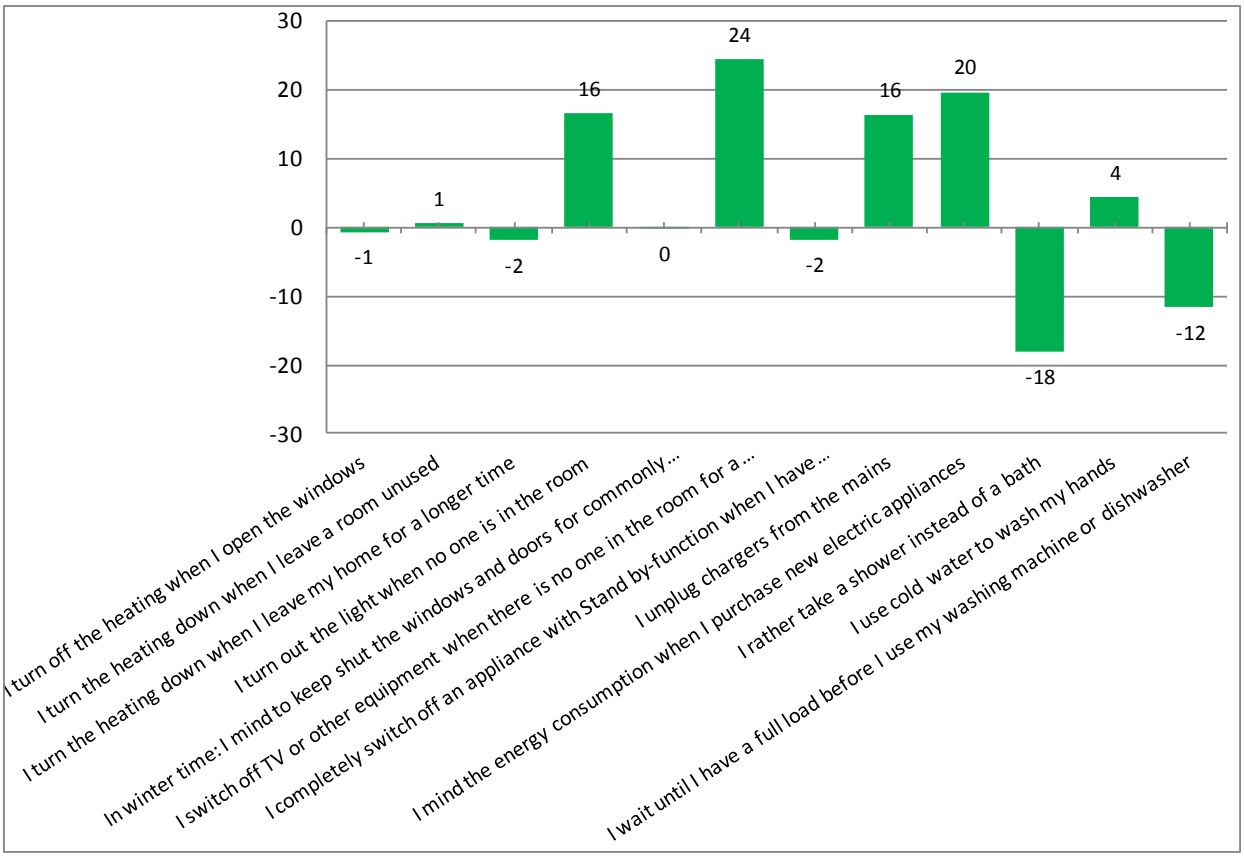
From these results it can be concluded that the RUAS have an influence on four kinds of behaviour:

- turn out the light when no one is in the room,
- switch off TV or other equipment when no one is in the room,
- turn off the heating when opening windows and
- completely switch off appliances with stand by-function.

As already found for some other pilot sites, not all influences of the RUAS affect kinds of behaviours that are directly addressed in the tenant portal. But this is not really unusual, because often people need to start saving energy in general, but once they started, they try to do so in different domains.

[112] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.7.19: Differences between experimental group and control group at final stage
(n=30-31 for experimental group and n=13 for control group due to missings[113]; percentage point differences for answer categories “strongly agree and rather agree”)



Ventilation behaviour

The following figures show the ventilation behaviour of both groups at final stage. As pre-post comparisons are not possible, because the question was modified at final stage, the analyses are based on the tenants who participated at least in the final survey.

It can be observed that both groups are ventilating all rooms mainly in a pro-ecological manner. Nearly half of the tenants in each group open windows widely at times. Many tenants also leave windows ajar at times which can be a second best solution if the time period of tilt ventilation is limited. It is positively striking that almost no one leaves windows ajar often or all times. As there are no major differences between both groups, the ventilation behaviour seems not to be influenced by the RUAS use. In addition to that, the experimental group tenants more often leave windows ajar over a period of at least 1 hour a day (51%) than the control group tenants (32%). This means that the control group more often behave in an energy saving manner.

[113] Answer categories „not applicable” and “don’t know” were coded as missing.

Figure 4.7.20: Ventilation behaviour of exp. group tenants in winter time (final stage)
(n=79-82 due to missings[114]; percentage)

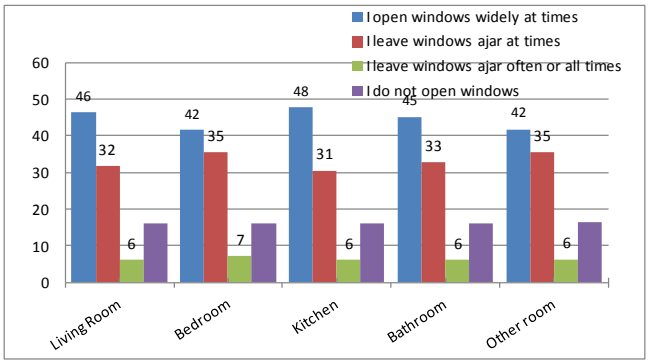
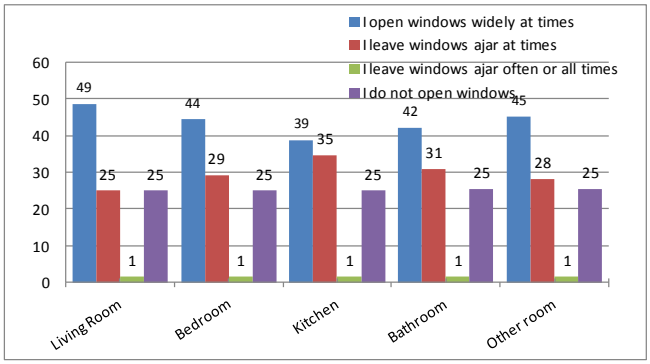


Figure 4.7.21: Ventilation behaviour of control group tenants in winter time (final stage)
(n=71-72 due to missings[115]; percentage)



Room temperature and use of air conditioning

For the room temperature pre-post comparisons are possible. Therefore the sample is restricted again to tenants who have participated in both surveys. In the experimental group the average room temperature at baseline stage is 21 degree for much used rooms and 19 degree for little or unused rooms. At final stage the room temperature remains constantly for much used rooms and increases to 21 degree for little used rooms. In the control group the room temperature increases from 20 degree to 21 degree in much used rooms and from 19 degree to 21 degree for little used rooms.

These results show that the RUAS did not contribute to lower the room temperatures. But it has to be mentioned that 21 degree can be seen as positive from an energy saving point of view. Generally 20 degrees represent the recommended indoor temperature (without taking into account that personal needs can largely differ).

As only four tenants have got an air conditioning system, analyses are not useful.

Retrospective and prospective behaviour

The question about the influence of the tenant portal on the behaviour and the questions about the planned behaviour have only been asked to the active users. The only active user states not to know whether he/she did change the behaviour as a result of the portal usage. But the tenant intends to conserve heat energy next winter and to save electricity/water in future (answer category: “rather yes”). This shows that a potential for future changes of behaviour and a reduction of energy consumption is given.

In summary, it can be stated, that the RUAS services show little influence on the ecological behaviour of the tenants. This seems to be caused by the fact that especially the experimental group showed an already high level at baseline stage and the potential for improvement therefore is rather small. At the same time there seems to be a general trend towards a decline of the ecological behaviour that is visible in both groups. However, for some kinds of the everyday behaviour influences of the RUAS services have been observed. These are related to heat energy (turn off heating when opening windows) and electricity consumption (turn out light when no one is in the room; switch off TV or other equipment when there is no one in the room; completely switch off appliances with stand by-function). Such spill-over effects are quite usual

[114] Answer category „not applicable/no window in room” was coded as missing.

[115] Answer category „not applicable/no window in room” was coded as missing.

once people have generally started to save energy. With respect to the ventilation behaviour, room temperatures and the retrospective question about the ecological behaviour no effects of the RUAS have been visible.

Satisfaction with tenant portal

The questions about the satisfaction with the tenant portal and the usefulness of information have been asked to active users only.

The active user of the tenant portal states to be rather satisfied with the tenant portal in general. He/she considers the consumption figures regarding the average consumption of the building/neighbourhood (comparative feedback) and the figures for the consumption history over several time periods (historical feedback) as very useful. The room temperature is judged as rather useful. Additionally, he/she considers tips for saving water as very useful.

Aspects dealing with the handling of the portal and the presented information are judged mainly as satisfactory. So the tenant is rather satisfied with the clarity and the amount of the provided information and the comprehensibility of the consumption data. With respect to the manageability of the portal the tenant is neither satisfied nor dissatisfied and with respect to the confidentiality of the provided information he/she is not decided (answer category: “don’t know”).

The tenant faced no problems during the usage of the portal and intends to use the tenant portal frequently in future.

4.7.4 Results of combined analysis

In Torino combined analyses for heat energy, hot and cold water consumption are possible. Due to some remarkable changes in the ecological awareness of tenants and / or differences between control group (RUAS) and experimental group (RUAS) that have been assessed within the survey analysis (see section 4.7.3), the correlation between ecological awareness and energy savings will be examined.

Although the survey analysis not always shows an increased ecological behaviour of the experimental group, the combined analysis will furthermore focus on the relation between behaviour and energy consumption.

Subjective energy saving norm and energy consumption

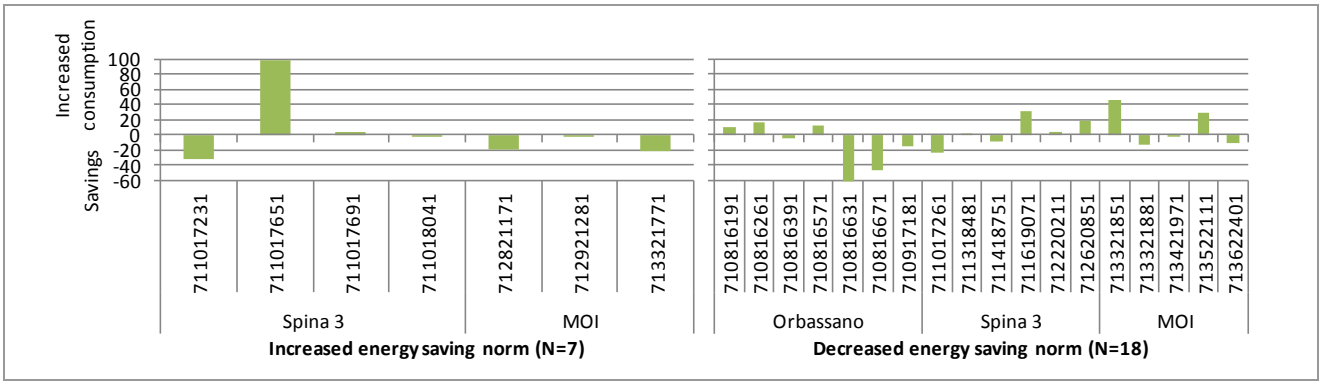
The following analysis examines the relation between the subjective energy saving norm (“I think I should save more energy at home”) and the savings achieved by the tenants. The focus is on the question whether tenants with increased energy saving norm during the project show higher savings than tenants with decreased or constant energy saving norm.

In the baseline survey, the majority of tenants who participated in both survey stages (51%) reported on a strong energy saving norm (answer category: strongly agree). At the final survey this proportion has decreased to 16% (7 out of 44 tenants). This decrease is mainly caused by a shift from the answer category “strongly agree” to “rather agree”. Therefore it is of interest, whether a decreased subjective energy saving norm leads to less savings/increased consumption than an increased energy saving norm. The analyses are restricted to tenants with available information about the change of energy saving norm and energy consumption. Therefore the analysis is only possible for heat energy and cold water consumption.

Heat energy consumption

With respect to heat energy, tenants with decreased energy saving norm on average saved 0.9% and tenants with increased energy saving norm consumed 3.4% more heat energy. As the averaged values might be biased due to extreme values in small samples, the following figure shows the percentage changes in heat energy consumption for both groups per dwelling.

Figure 4.7.22: Percentage change in heat energy consumption for tenants with increased and decreased energy saving norm



It becomes obvious that the five out of seven tenants with increased energy saving norm achieved savings. But eight out of 18 tenants with decreased energy saving norm also achieved savings. The figure also reveals that the above mentioned increased consumption for tenants with increased energy saving norm is due to one tenant who has increased his consumption by 97.5%. In addition to that, in the subgroup of tenants with decreased energy saving norm, there are two tenants who achieved very high savings of more than 40%.

It should be also pointed out, that the heat energy consumption was subject in all three sub-pilots of Torino, but that the service setups are very different. RMS that has largely influenced the heat energy consumption (see section 4.7.2) was only available in Orbassano. At the same time, in the figure above, Orbassano is only represented within the tenant group with decreased energy saving norm and the tenants with the highest savings belong to Orbassano. This means that a part of the savings is assumed to be mainly due to the RMS in Orbassano, but not due to the energy saving norm.

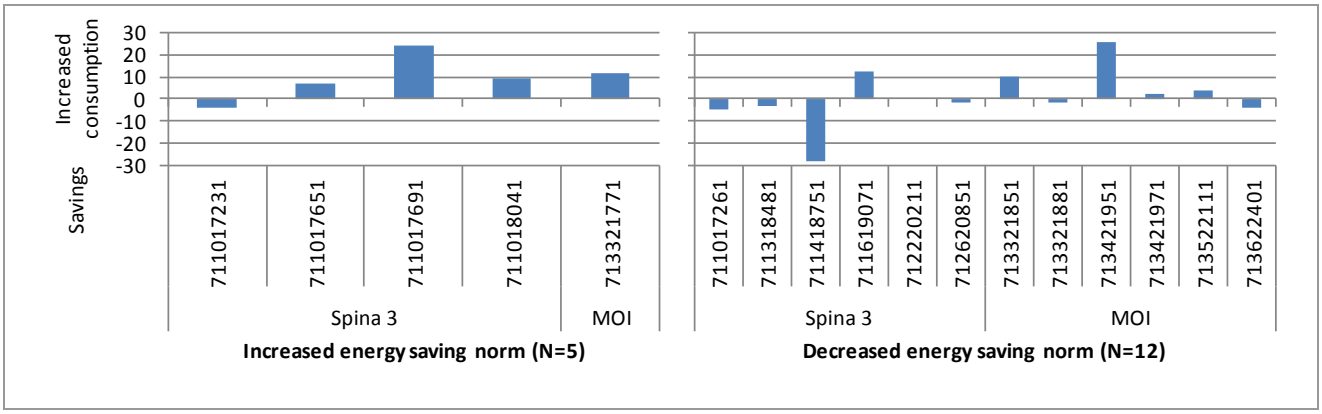
Taking this supplement information into account, the results can be interpreted as hints for positive influence of the energy saving norm on the achievement of savings related to heat energy.

Cold water consumption

With respect to the cold water consumption for tenants with decreased energy saving norm can be found an increased consumption of 1.0%. Tenants with increased energy saving norm have an even higher increased consumption of 9.6%.

As before, the individual percentage changes in water consumption are considered per dwelling in the figure below. It is shown that an increased energy saving norm does not lead to savings in cold water consumption as only one out of five tenants achieved (small) savings. For tenants with decreased energy saving norm no clear trend can be found. In this subgroup the majority of tenants show only little percentage changes. Remarkable percentage changes of at least 10% can be found for three tenants with increased consumption and one tenant who achieved savings. The findings seems to be not related to the sub-pilots, to the initial baseline consumptions per capita, evaluation group status or the degree of the energy saving norm that varies largely.

Figure 4.7.23: Percentage change in cold water consumption for tenants with increased and decreased energy saving norm



In summary, the findings for the relation of energy saving norm and achieved savings respectively increased consumptions suggest that in the case of Torino there is no major potential to reinforce the savings by trying to influence the energy saving norm of tenants more effectively.

Personal interest in energy saving issues and electricity consumption

The personal interest in the energy consumption at home and the personal interest in possibilities of saving energy at home – gathered in the survey – increased remarkable during the project (based on answer categories strongly agree and agree) (see section 4.7.3). As before, it is of interest whether a change of personal interest is related to the achievement of savings.

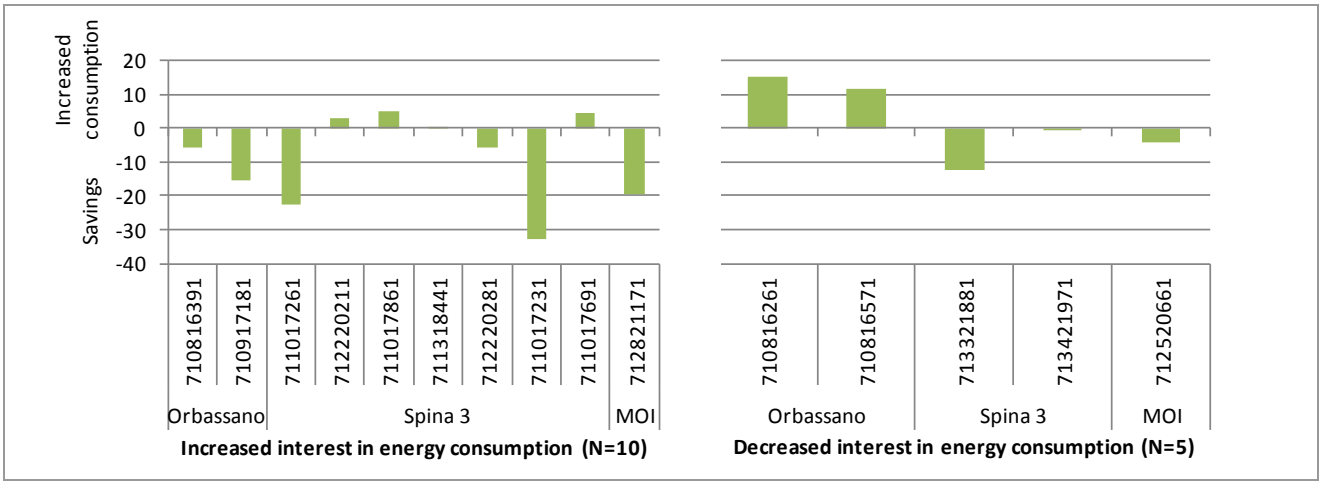
Independent from the evaluation group, at the baseline stage 83.3% of tenants agreed to be interested in their energy consumption at home, at the final stage there were 97.7% of tenants with this opinion. With respect to the interest in possibilities of saving energy at home, the proportion raised from 74.4% to 95.5%. Considering the individual changes, for both kinds of interest there are eight tenants with decreased interest and 12 tenants with increased interest.

Heat energy consumption

The following figure shows the percentage changes in heat energy for tenants with increased and decreased personal interest.[116] Although the sample sizes are quite low, it can be found that tenants with increased interest in their energy consumption at home show more often and higher savings than tenants with decreased interest. This result seems not to be biased by the sub-pilots (as assumed before for the influence of energy saving norm). Therefore it can be concluded that the achievement of savings is influenced by the change in the interest in the own energy consumption at home. This result is also confirmed by the average percentage changes in heat energy consumption. Tenants with increased interest achieved 8.9% savings whereas tenants with decreased interest consumed 2.1% more heat energy than during the baseline period.

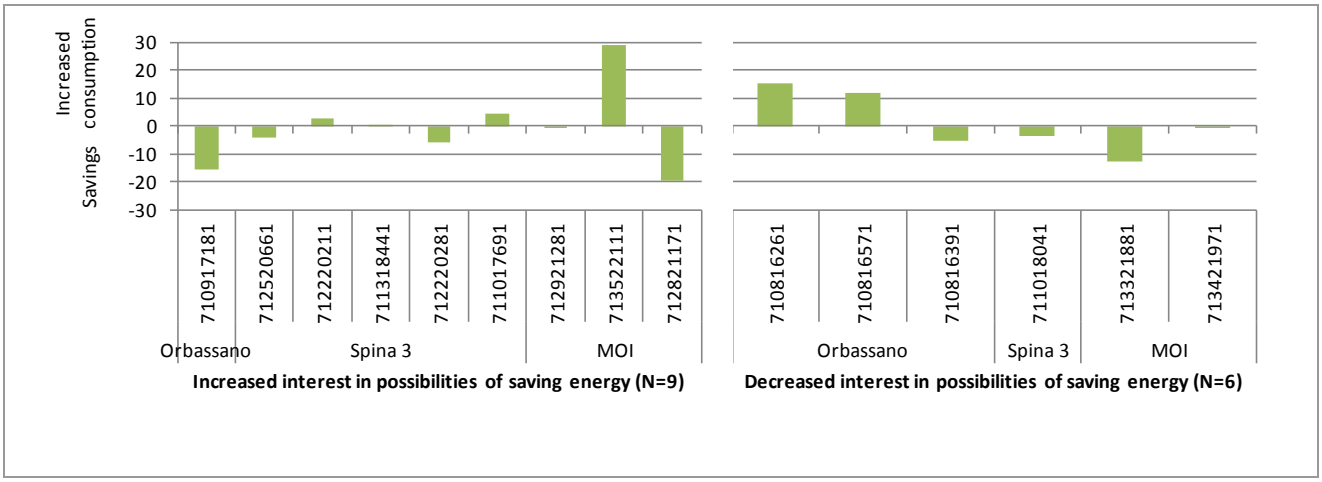
[116] The sample is reduced to dwellings where consumption data is available.

Figure 4.7.24: Percentage change in heat energy for tenants with increased and decreased interest in their energy consumption at home



The influence of the interest in possibilities of saving energy at home is less obvious. The majority of tenants with increased interest in possibilities of saving energy at home achieved savings, but the same is true for tenants with decreased interest. However, the savings achieved by tenants with increased interest are somewhat higher. There seem to be no interfering influences of the sub-pilots or the initial baseline consumption. But the good performance of tenants with decreased interest might be partly explained by the fact that their interest is still rather high (all tenants rather agree to the item at final stage). The little influence of the personal interest in possibilities of saving energy at home is also reflected by the average percentage changes. Tenants with decreased interest consumed 1.0% more heat energy than during the baseline period whereas tenants with increased interest saved 1.0% heat energy.

Figure 4.7.25: Percentage change in heat energy for tenants with increased and decreased interest in possibilities of saving energy at home



In summary, the findings on the influence of personal interests in energy saving issues shows reinforcing such an interest by services as provided in BECA may help to achieve higher savings. Torino pilot site is already well on the way as the interest of tenants increased during the project. However, as the control group showed even stronger increases, the power of the RUAS can still be improved.

Cold water consumption

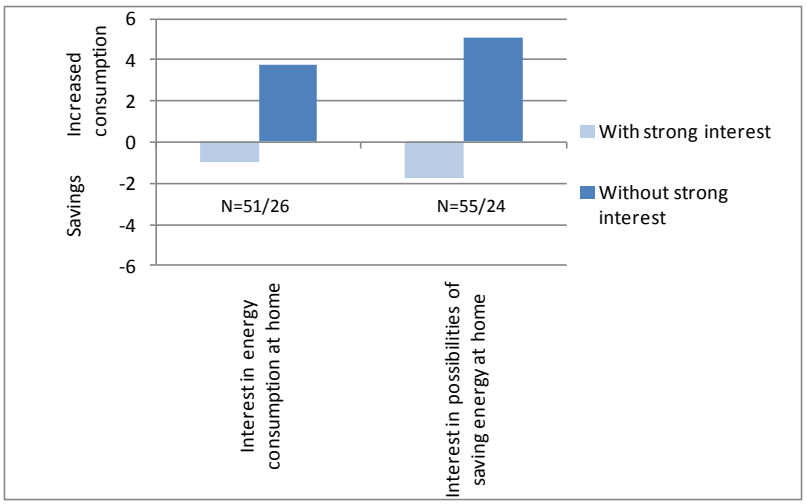
Due to the small sample sizes analyses of the change of personal interest related to water consumption are not possible. Instead, it is examined whether tenants with strong interest (tenants who “strongly agree” with the item) achieved higher savings than tenants with smaller interest (tenants who do not strongly agree with the item). In doing so, statements about the relation between interest and cold water savings can be made.

At the final stage there are 62% of tenants with strong interest in their energy consumption at home and 65% with strong interest in possibilities of saving energy at home.

The following figure shows that for the interest in energy consumption at home and in possibilities for saving energy at home there is a great difference between tenants with strong interest and tenants without strong interest. In both cases tenants with strong interest saved cold water whereas tenants without strong interest had a water consumption increase. Although the savings are not very high, the big differences between both tenant groups suggest an influence of the interests on the achievement of savings.

The dwelling-wise consideration (not shown) confirms these findings as the savings of tenants with strong interest are generally higher than for tenants without strong interest.

Figure 4.7.26: Percentage change in cold water consumption for tenants with strong and without strong interest in energy saving issues



Everyday ecological behaviour and energy consumption

In the following section the ecological behaviour reported in the final survey is analysed with regard to the measured energy consumption during the reporting period.

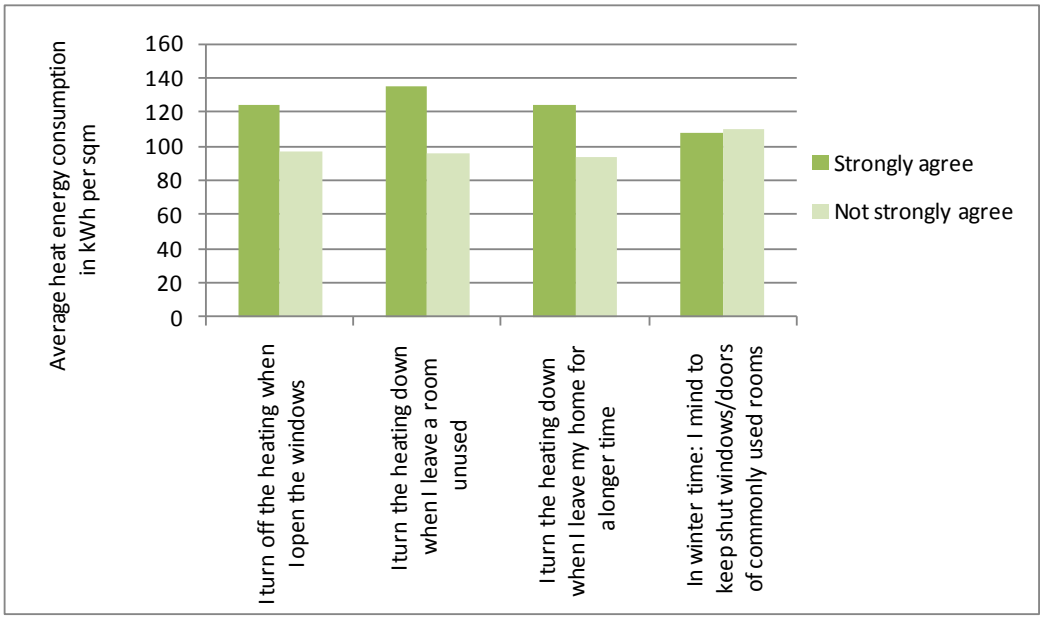
Heat energy consumption

The first part focuses on heat energy consumption with available information about following activities:

- turning off the heating when opening windows;
- turning down the heating when leaving a room unused;
- turning down the heating when leaving the home for a longer time;
- mind to keep shut windows and doors of commonly used rooms in winter time.

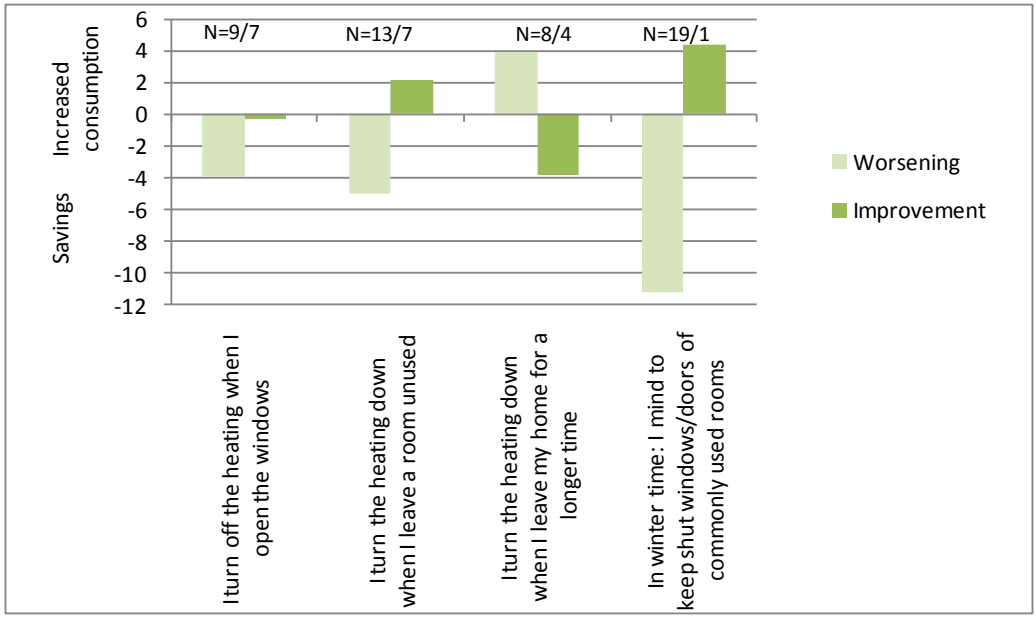
It becomes obvious that the behaviour items seem not to be related to the heat energy consumption as assumed. For three of the items tenants who do strongly agree consumed more energy than tenants who do not strongly agree. For keeping shut windows and doors of commonly used rooms in winter time there is no difference remarkable.

Figure 4.7.27: Heat energy consumption (reporting period) of respondents with and without ecological behaviour reported in final survey



As this analysis only gives a first impression on the relation of heat energy behaviour and consumed energy, additionally the changes of behaviour are considered in relation with the achieved savings/increased consumptions. In doing so, different results can be found. For most of the behaviour items an improved behaviour does not lead to a better energy performance. Only for the item “I turn the heating down when I leave my home for a longer time” tenants with improved behaviour achieved savings whereas tenants with worsened behaviour consumed more energy than before.

Figure 4.7.28: Percentage change in heat energy consumption for tenants with worsened and improved ecological behaviour



It has to be pointed out that these results have to be treated carefully due to the small sample sizes and the different setups in the three sub-pilots of Torino.

Taking a closer look on the behaviour item “I turn off the heating when I open the windows” it has to be noticed that tenants with worsened behaviour more often belong to Orbassano (4 out of 8

tenants), the only sub-pilot where RMS was provided, than tenants with improved behaviour (1 out of 7 tenants). Two of those tenants achieved very high savings of 46.2% and 60.4%. As the consumption analysis found a great impact of the RMS, it is assumed that these savings are mainly due to the RMS and the behaviour is less relevant. In each case, these enormous savings carry weight when calculating the average saving. On contrary, there is also one tenant living in Spina 3 with an enormous increased consumption of 97.5% that also carries weight on the average savings. It has to be noticed that heat energy in Spina 3 is including water heating, but as tenants of Spina 3 are equally represented in both tenants groups with improved and worsened behaviour, this cannot be an explanation.

The same argument as above is appropriate when considering the items “I turn the heating down when I leave a room unused” and “I mind to keep shut windows/doors of commonly used rooms”. Among the tenants with improved behaviour there is no tenant of Orbassano (each item). Among the tenants with worsened behaviour there are five tenants from Orbassano in each case. Additionally, there are the same two tenants with very high savings that might explain the average savings shown in the figure above. In addition to that, tenants with improved behaviour for keeping shut windows and doors of commonly used rooms have a rather high heat energy consumption during the baseline period that is for most tenants above the average and which might allow higher savings.

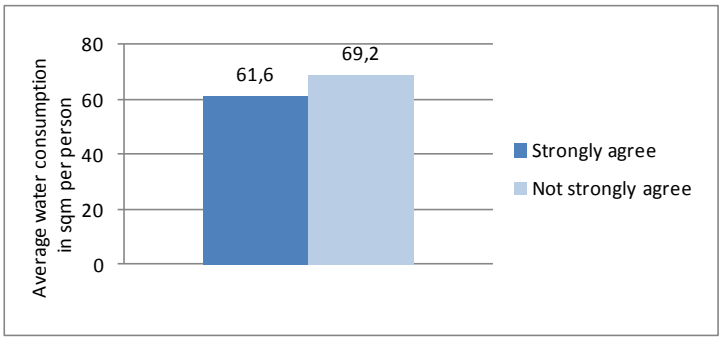
With respect to the only item that showed the expected results (“I turn the heating down when I leave my home for a longer time”), it has to be noticed that the two Orbassano tenants with very high savings belong to the tenant group without behavioural change and therefore are not included in the average calculation. At the same time Orbassano tenants are represented more equally in both tenant groups.

Despite these explanations, it cannot be concluded that an improvement of the three behaviour items (“I turn off the heating when I open the windows”; “I turn the hating down when I leave a room unused”; “I mind to keep shut windows/doors of commonly used room”) helps to achieve higher savings of heat energy. In contrary, an improvement of the behaviour item “I turn the heating down when I leave my home for a longer time” seem to contribute to a higher achievement of savings. However, due to the small sample sizes and the RMS of Orbassano that might interfere with the influences of behaviour does not allow a reliable conclusion on that topic.

Cold water consumption

With respect to taking a shower instead of a bath, the ecological behaviour seems to be related to the cold water consumption per person. At least tenants who strongly agree with this behaviour item (n=45) have a lower cold water consumption during the reporting period than tenants who do not strongly agree (n=40).

Figure 4.7.29: Cold water consumption (reporting period) of respondents with and without ecological behaviour reported in final survey: “I rather take a shower instead of a bath”

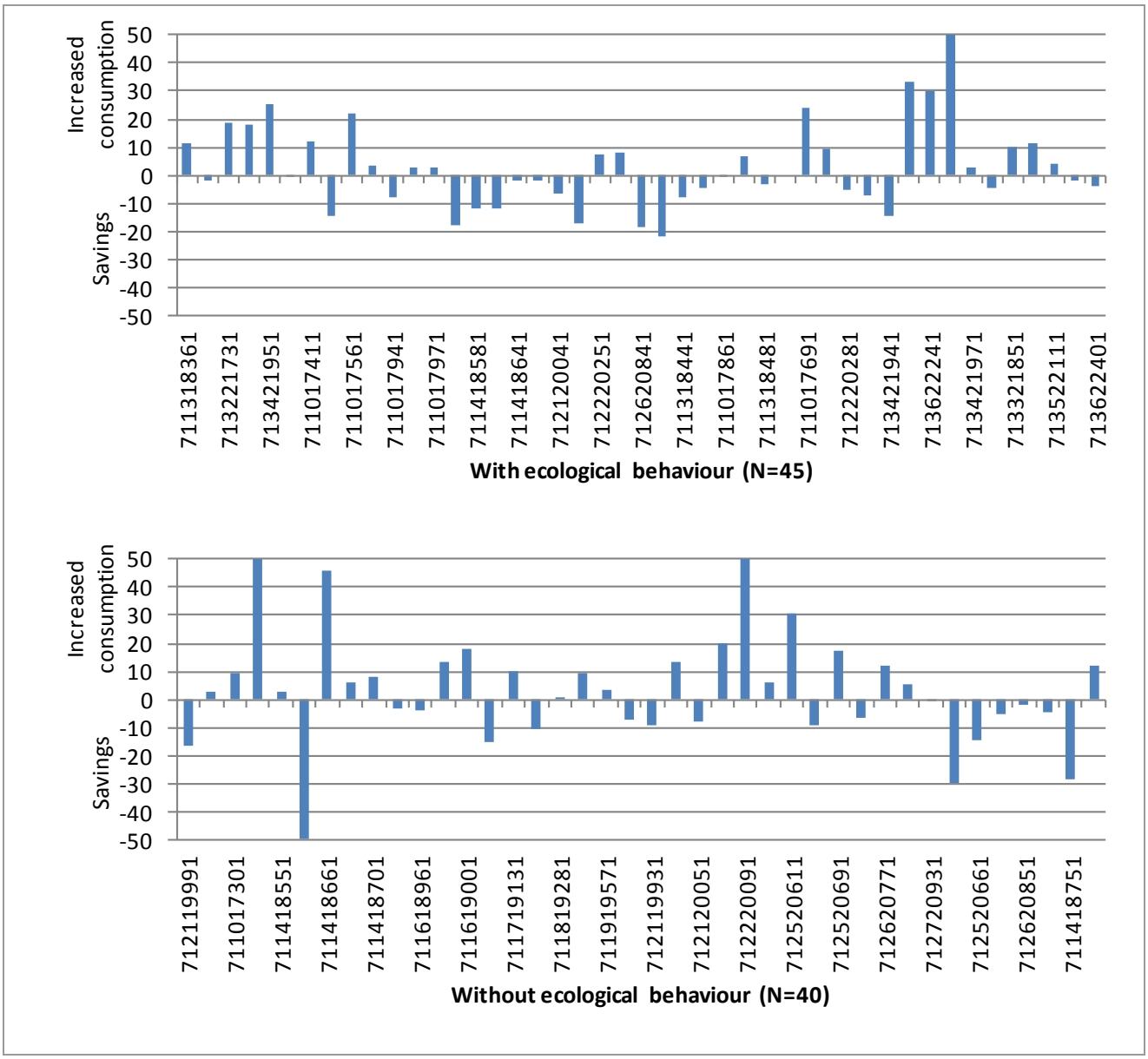


The following figure shows the dwelling-wise percentage changes in cold water consumption for tenants with (strongly agree) and without (not strongly agree) ecological behaviour related to showering instead of bathing.

It becomes obvious that the behaviour has not a remarkable influence on the achieved savings as no clear pattern can be observed. 23 out of 45 tenants with ecological behaviour and 18 out of 40 tenants without ecological behaviour achieved savings. The quite similar results for both tenant groups might be explained by the fact that the level of ecological behaviour for tenants who do not strongly agree to the behaviour item is still rather high (31 out of 40 tenants rather agree with the item). Therefore it might be that the difference between both tenant groups is not big enough for being able to identify the influence on the achieved water savings.

As the sample sizes are too small for doing analyses for tenants with increased and decreased behaviour, this relation cannot be further analysed.

Figure 4.7.30: Percentage change in cold water consumption for tenants with and without ecological behaviour: "I rather take a shower instead of a bath"



On the basis of these analyses, it cannot be concluded that taking a shower instead of a bath has a remarkable influence on the achieved savings.

5 Conclusions and outlook

The resource management services (RMS) and resource user awareness services (RUAS) operated in BECA have been evaluated as meaningful instruments to achieve significant savings in resource and energy consumption, to raise the ecological awareness of tenants and to help them improving their ecological behaviour.

The BECA project equipped 2,300 dwellings in social housing contexts with metering equipment for the monitoring of their energy and resource consumption. Among those dwellings, 1,524 dwellings have been part of the experimental group. The remaining dwellings were established as control group with metering equipment installed, but without access to the services during the project.[117]

The services were aimed at supporting tenants in saving energy in different social housing dwellings in seven pilot sites all over Europe. This enabled 3,353 tenants (calculated with an average household size of 2.2 persons) to benefit from the services.

The majority of pilot sites has achieved or even overachieved the targets they set prior to the project. For resources where targets were not fully met, there are good reasons to believe that consumption can be further reduced as the majority of tenants intends to use the tenant portal frequently in future, and changing the habits often needs a longer time period.

However, there are huge differences in the savings of the pilot sites which illustrate the importance of individual contexts, conditions and dispositions in the national societies for the achievement of savings. With respect to heat energy consumption the pilot sites at Darmstadt and Örebro achieved the highest savings of 20% and 19% which is mainly due to the RMS that automatically optimises the supply water temperature in the case of Darmstadt and sets the indoor temperature at a maximum of 21 degree at Örebro. Related to cold water consumption Belgrade and Örebro achieved the highest savings of 16% and 37%. These high savings in Örebro are again due to a specific condition introducing a new billing system with now water expenditure calculation on the basis of the actual consumption of the tenant households. This made tenants very responsive to the RUAS services. At Belgrade the experimental group tenants showed a striking increase in their subjective energy saving norm, therefore felt responsible to save energy and improved their behaviour related to water consumption. The highest reduction of hot water achieved again Örebro due to the above mentioned reasons (35%) and Torino (31%) where the mainly elderly tenants with low pensions have been highly motivated to save money. Regarding electricity consumption that was part of the project at three pilot sites, Ruse achieved the highest savings with 6%. That very likely might be related to their specific focus on the high consumers.

Across all pilot sites the BECA project achieved average savings of 15% for heat energy, 11% for cold water, 17% for hot water consumption and 2% for electricity.

This shows that the target of the European Commission of 15% savings has been achieved for heat energy and overachieved for hot water consumption when considering the average global savings. Space and water heating normally have the biggest influence on energy consumption of private households, so even that result confirms already the very positive impact of the BECA project. For cold water consumption the saving target has been overachieved when considering the top performing pilot sites, although the overall average savings were below this target. Only for electricity the target was not met yet. But it has to be taken into account that the most effective way to achieve meaningful electricity savings is to replace old electric appliances by new and less energy consuming ones. The tenants of social housing often do not have the means for doing so and assess it as not useful to replace appliances when the old ones still work well.

[117] Before carrying out the data analysis, all dwellings were subject to a sophisticated data cleansing process. That's why the analysis based on a lower number of dwellings (see section 2.1.2).

Regarding the ecological awareness and behaviour of tenants, several positive findings could be observed. At all pilot sites tenants show an increased ecological awareness (for some awareness statements under consideration). The same applies to the ecological behaviour of tenants whereat an improvement mostly became visible not only for practices that are related to resources the BECA services addressed in the tenant portal, but also for resources not being part of the RUAS. Such spill-over effects indicate that even when tenants once have started watching out for their ecological behaviour and to change their practices, they do so in all domains of energy use.

In the combined analyses of consumption data and survey data have been observed various relations between ecological awareness as well as ecological behaviour and the achievement of savings. At most pilot sites there can be observed that a high or increased energy saving norm ("I think I should save more energy at home"), a high or increased interest in saving energy at home and in possibilities of saving energy at home led to higher savings. At one pilot site the data allowed for analysing the relation between the retrospective view of the tenants and the achieved savings. The results revealed that tenants who stated to know more about their energy consumption due to the tenant portal or stated that they keep an eye on their energy consumption really performed better than tenants who do not think so.

In addition to that, the analyses revealed for several statements a relation between the ecological behaviour and the achieved savings. With respect to electricity consumption, to mind the energy consumption when purchasing new appliances (as assumed and mentioned above) showed the strongest influence on electricity consumption among the everyday practice related to electricity consumption. Related to water consumption the use of cold water for washing hands and taking a shower instead of a bath have been identified as most relevant practices of water consumption. The heat energy consumption was mainly influenced by turning off the heating when opening windows and turning down the heating when leaving the home for a longer time.

In general, the combined analysis illustrates that the RUAS not only supported tenants to raise their ecological awareness and to improve their behaviour, but also that these developments effectively contribute to the achievement of savings. That's why the RUAS can be considered as useful instruments for the achievement of durable reduction of energy. However, it has to be pointed out that some of those analyses are subject to very small sample sizes, which, in some cases, made it difficult to interpret the results.

All these achievements have to be seen against the background of a very short operation phase of just one year which is a short time period for tenants to get aware of how they can behave more ecologically, to break with their current behaviour and to form new habits that additionally must match the conditions of their everyday life. In addition to that, the project with social housing tenants addressed a very specific target group that has got many other problems and therefore might not be interested in energy saving issues and that is not very familiar with the use of computers and internet (which was a major subject in Darmstadt and Torino). For all those reasons even more savings are expected in future when there is more time to raise the tenants' interest in using the services, to make them familiar with ICT and to give them time for adapting their behaviour.

Furthermore there is some evidence that the improvement of behaviour and the achievement of savings are related to the frequency of portal logins. At most pilot sites medium and or heavy portal users performed better than weak users. That's why tenants should be motivated to use the services quite regularly. Therefore a character such as BECO at Manresa that has been evaluated as helpful for paying attention to the project could be used. However, a frequent portal use of tenants requires frequently updated and new information for keeping the tenants motivated.

One more important insight of the project is that the developments that can be caused by ICT services are strongly depending from the initial situations at the pilot sites. This is true for the achievement of savings as well as for the improvement of behaviour or the increase of ecological awareness. Every time that the energy consumption is low or the level of behaviour and awareness is high already before the operation of the services, the potential for savings and improvements is low. That's why it was hard for some pilot sites (such as Manresa) to achieve high amounts of

savings or to improve the behaviour (e.g. Torino). At the same time, this is the reason why the experimental groups not always performed better than the control groups.

Due to these largely varying conditions it is difficult to draw conclusions about the influence of single aspects of the services. However, the results suggest that the RMS generally is more effective than the RUAS. In that context one important advantage of RMS is that its effects inure to the benefit of whole buildings. As a consequence the optimal service setup seems to be the provision of combined RMS and RUAS which can bring out the potentials lying in optimising operations of buildings together with optimised user behaviour. This is also shown by a building-wise analysis on heat energy consumption where buildings with RMS and RUAS achieved the highest savings. Furthermore this analysis suggests that RMS technologies that automatically regulate energy related features (such as Techems' adapterm or setting a limit room temperature) have a bigger impact than systems that serve as monitoring instrument for detecting malfunctions that in a second step can be fixed by the staff members.

Within the RUAS, using paper reports or offering a service hotline to tenants in addition to the web-based services are important for achieving its objectives. This is demonstrated by the fact that tenants of the experimental group who did not became active portal users also achieved meaningful savings (e.g. in Belgrade or Havirov).

In addition to that a focus on high consumers is a very promising approach as shown by the services provided in Ruse. Due to the coaching of high consumers, they have been enabled to reduce their consumption. The success of this approach is especially proven by the savings that have been achieved for electricity consumption where the potential for savings in the experimental group has been very low. The fact that high consumers are more responsive to the services is also proven at Belgrade and Darmstadt.

Furthermore it can be assumed that the forecasting of costs based on the energy consumption of the households (available at Örebro) is one more successful feature that, when offered in addition to the consumption figures, helps to achieve higher savings and keep the tenants motivated.

One more important program-external context factor that seems to be important for the achievement of savings and the potential for the improvement of ecological behaviour of tenants is the billing system used. The saving potential is particularly high when the billing system is changed in conjunction with the service operation from expenditure calculation on the basis of square meter or a billing system with a fixed rate included in the rent into a calculation on the basis of the actual consumption of the households (as in Örebro). We identified that the potential is also high in cases where the energy consumption calculation had already been based on the individual consumption of households prior to service operation. In these cases the tenants are much more motivated to change their behaviour and try saving energy (this could especially be observed among high energy consumers such as in Ruse) than in pilot sites with a billing system based on the size of the dwelling instead of real consumption (e.g. Havirov, Belgrade).

Of course there are even more externalities that may have an impact on the energy savings. In the socio-political and the scientific discourse about the possibilities to achieve energy savings in the domain of public and residential housing, regularly the question arises as to the influence of building-types on the impact of energy saving measures. This is an interesting question also for the BECA services. Although not being in the focus of the project, an analysis related to heat energy showed that for buildings where RMS and RUAS are provided the savings potential is higher for buildings with rather high energy performance (low heat energy consumption during baseline period) and is lower when the energy performance of buildings is rather poor (high heat energy consumption during baseline period). However, in cases where the energy performance is very high through the use of very new heating systems, the savings potential also seems to be limited. This is especially true where the tenants also had a rather high level of ecological behaviour before starting the services.

However, it has to be mentioned that these results have to be treated carefully, because the single effects of building-types and further externalities cannot be clearly (statistically) separated or even

quantified. Therefore a specific research design would be needed where the factors of interest (e.g. building-types, billing system) are systematically varied across the research units whereas others are kept constant (e.g. service) to allow for multivariate analyses. This was not the focus of the BECA project and is hardly possible in a pilot study, but, on the contrary, BECA tested different services under different real conditions within social housing and the project has proven that the services work in those different contexts. It also revealed that savings could be achieved independent from building-types and other specific conditions. In doing so, a control group approach was used in addition to pre-post comparisons in order to exclude unwanted effects resulting from externalities and to achieve robust savings results. Despite the huge heterogeneity of pilot sites, the savings results are comparable because unique instruments and calculations procedures have been used. Differences have been taken into account in the interpretations given.

Overall, the BECA project already revealed a great success that can even be enlarged by extending the operation period of the services, giving the tenants more time to adapt their behaviour. As all pilot sites will continue the provision of their services they can base their future campaigns, energy coaching and further activities on the current success of the project and the lessons learned that are described in the BECA guide for replication. They can tell their tenants what they have achieved so far, that they personally are able to influence their consumption and costs by an improved behaviour and that the services will help them to succeed. Such activities based on the results of BECA and maybe including reports from very successful or satisfied portal users are very likely to gain more tenants as active users, to support the confidence of tenants in the services and their own capabilities for the achievement of further savings.

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