EEPOS - Energy management and decision support systems for energy positive neighbourhoods

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Usability study

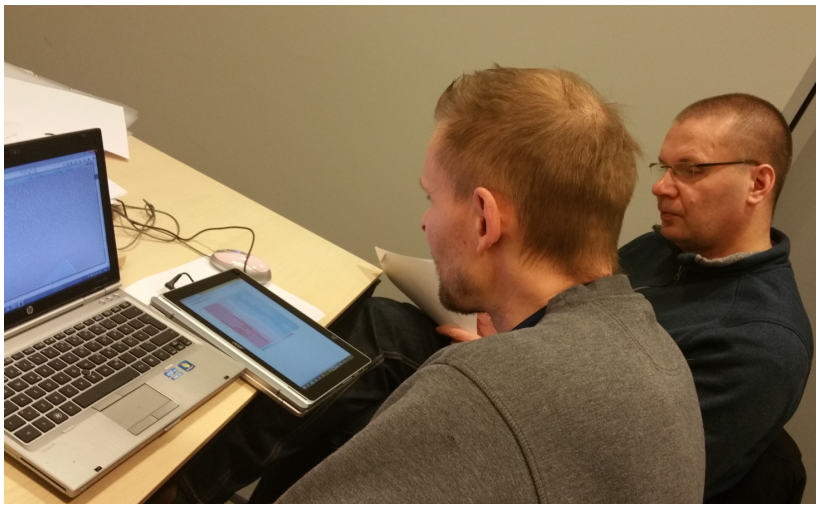

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Table of contents

1. PUBLISHABLE EXECUTIVE SUMMARY

In this task (Task 4.5) usability of several energy management tools developed in other WPs and tasks was studied.

Usability refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO 9241-11). Making systems more usable contributes meeting user and organisational needs better. The benefits include (ISO 13407) that the solutions are easier to understand and use, thus reducing training and support costs; improve user satisfaction; improve the productivity of users and operational efficiency of organizations; and improve product quality, appeal to the users and can provide a competitive advantage.

The main purpose of the energy management tools is to save energy. It is highly probable that the energy savings are higher with a tool that has a high usability and provides relevant and understandable information than with a tool that has serious usability problems.

The study methods in this task involved both expert reviews (heuristic evaluation) and user tests in which test participants tried to accomplish pre-defined tasks. In the user tests the completion rates were recorded and verbal feedback was gathered. In addition, short questionnaires were performed after the tests in certain cases.

It is recommendable that usability tests are performed several times during the design process. The problems found should be fixed and a version of the new prototype should be developed. It is better to perform usability tests early in the development phase than late since more changes can be made to early prototypes than to late ones.

The results of the usability studies were delivered to the developers of the tools to be used in improving the usability of the tools. A simple way of presenting the results was applied: the tables show 1) recommendation (what to change), 2) justification (why) and 3) severity rating (high/moderate/low).

This task was planned to be performed during a period of one year. The first usability tests were performed soon after the beginning of the task (spring 2014) for all the tools of which a prototype was available. More usability tests were performed during the autumn of 2014 and the spring of 2015. In all the periods the tests involved those tools of which a new prototype was available for testing.

The usability tests revealed a large number of usability problems, some of them with a high severity rating. The test users generally encountered similar usability problems with each other. This gave clear ideas on how to improve the usability of the tools. Fixing the problems with a high severity rating is essential for improving the usability of the tools but it is recommended to fix all the problems found. A part of the usability problems have already been fixed during the running time of this task.

2. INTRODUCTION

2.1 Purpose and target group

The purpose of the document is to present results of the usability study that involves expert reviews and user tests.

The results give feedback on the design of the selected energy management applications. This feedback will be used during the project to improve the usability of the final designs.

2.2 Contributions of partners

VTT was responsible for leading the task. VTT performed the general planning of the task together with the other partners. VTT prepared templates for the expert reviews and user tests.

VTT and other Finnish partners (CAV, FTM) were responsible for performing the usability studies of Finnish tools (BimZone, Energy Brokering Tool, Energy Performance Monitoring Tool). The first usability tests were performed soon after the beginning of the task (spring 2014) for all the tools of which a prototype was available. More usability tests were performed during the autumn of 2014 and the spring of 2015. In all the periods the tests involved those tools of which a new prototype was available for testing. Table 1 shows an overview of usability studies performed by Finnish partners. The results are presented in chapters 4−9.

Table 1. Usability studies performed by Finnish partners (VTT, CAV, FTM)

Date	**User group involved in the user tests**	**Tools studied**
Spring 2014	Facility management	BimZone, Energy Brokering Tool, Energy Performance Monitoring Tool (Unity)
Autumn 2014	End users (occupants)	Energy Performance Monitoring Tool (Unity)
Spring 2015	Facility management	Energy Brokering Tool, Energy Performance monitoring Tool (Unity)

AIT, DER and ENO were responsible for performing the usability studies of Austrian/German tools. The results of the work by DER are presented in chapters 10−11.

Partners' contributions are shown in the table below.

Table 2. Contribution of the partners

Chapter	Contributor
1, 2, 3, 4, 5, 6, 7, 8, 9, 12	VTT
4, 5	FTM
5, 9	CAV
10, 11	DERlab

2.3 Baseline

Usability refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO 9241-11).

- Effectiveness: the accuracy and completeness with which users achieve specified goals.
- Efficiency: the resources expended in relation to the accuracy and completeness with which users achieve goals.
- Satisfaction: freedom from discomfort, and positive attitudes to the use of the product.

Making systems more usable contributes meeting user and organisational needs better. The benefits include (ISO 13407) that the solutions are easier to understand and use, thus reducing training and support costs; improve user satisfaction; improve the productivity of users and operational efficiency of organizations; and improve product quality, appeal to the users and can provide a competitive advantage.

If users find serious usability problems with a tool they avoid using it. The main purpose of the energy management tools is to save energy. It is very probable that energy savings are higher with a tool that has a high usability and provides relevant and understandable information than with a tool that has serious usability problems.

It is typical the designers see that the solutions they developed are easy-to-use. The actual users, however, have a different perspective (and a different mental model), and often face serious problems with new products. To avoid this - or to reduce the usability problems - user tests should be performed with potential users as test users. The problems found should be fixed and a version of the new prototype should be developed. It is better to perform usability tests early in the development phase than late since more changes can be made to early prototypes than to late ones. Preferably usability tests are performed several times during the design process, i.e. this kind of iterative process is typical to user-centred design.

2.4 Relations to other activities

The usability of user interfaces of energy management tools developed in WP2, WP3 and WP4 is studied in this task. The usability studies include expert reviews and user tests. This task gives feedback to the designers of the tools and recommendations how to improve the tools based on expert reviews and user tests. This information is used to improve the usability of the final designs for demonstrations in WP5.

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3. METHODS

3.1 Introduction

Usability of the energy management tools is analysed by two complementary methods, by expert reviews and by user tests.

3.2 Expert reviews

An expert review is a heuristic evaluation of user interface. The idea is that experts review the user interface and compare it against usability guidelines. The analysis reveals a list of potential usability problems.

Ten Usability Heuristics by Nielsen (1995) are commonly used in expert reviews.

1. **Visibility of system status.** Appropriate feedback should always keep users informed about what is going on.

2. **Match between system and the real world.** The system should speak the users' language rather than system-oriented terms and make information appear in a natural and logical order.

3. **User control and freedom**. Users need a clearly marked "emergency exit" to leave the unwanted state. Undo and redo should be supported.

4. **Consistency and standards**. Users should not have to wonder whether different words, situations, or actions mean the same thing. Platform conventions should be followed.

5. **Error prevention**. Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

6. **Recognition rather than recall**. Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another.

7. **Flexibility and efficiency of use**. Systems should cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

8. **Aesthetic and minimalist design**. Dialogues should not contain information which is irrelevant or rarely needed.

9. **Help users recognize, diagnose, and recover from errors**. Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

10. **Help and documentation**. Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

For this work a more detailed version of the heuristics is available (if suitable for analysing a specific tool). An Excel template adapted from Anon 2011 is provided. The list of 41 usability guidelines is as follows.

Features & functionality

1	**Features and functionality meet common user goals and objectives** Key and common user goals and objectives (e.g. carry out some transaction, find some information, carry out some research etc…) should have been identified and addressed. Ideally the site or application should allow users to meet all of their key goals and objectives.
2	**Features and functionality support users desired workflows** The site or application should support or at least be compatible with the way that users wish to work. For example, users might want to be able to carry out bulk transactions or be able to save and return to their work.
3	**Frequently-used tasks are readily available and well supported** For example short cuts and a login to retrieve details might be provided to speed up the completion of frequently carried out tasks.
4	**Users are adequately supported according to their level of expertise** For example, novice users are given help and instructions and features are progressively disclosed (e.g. advanced features not being shown by default).
5	**Calls to action (e.g. register, add to basket, submit) are clear, well labelled and appear clickable** Possible actions should always be clear and the primary call to action (i.e. the most common or desirable user action) should stand out on the page or screen.

Homepage / starting page

6	**The Homepage / starting page provides a clear snapshot and overview of the content, features and functionality available** For example, an introduction and overview of the site is provided together with section snapshots and example content.
7	**The homepage / starting page is effective in orienting and directing users to their desired information and tasks** Users should be able to work out where they need to go to complete a given task (e.g. carry out some research, complete a transaction).
8	**The homepage / starting page layout is clear and uncluttered with sufficient 'white space'** Users should be able to quickly scan the homepage and make sense of both the content available and of how the site is structured.

Navigation

9	**Users can easily access the site or application** For example, the URL is predictable and is returned by search engines. If a user attempts to find the site via a search engine, it should ideally be returned on the first page of search results for likely queries.
10	**The navigational scheme is easy to find, intuitive and consistent** Users should be able to very easily locate and use the navigational scheme (e.g. left hand menu, top menu, tabbed menu), and it should not be significantly different across the site or application (unless a decision has been made to specifically differentiate a given section or area).
11	**The navigation has sufficient flexibility to allow users to navigate by their desired means** For example a user might want to be able to search for an item or browse by size, name or type. Although not all user preferences can or indeed should be addressed, the most useful and common navigational means should be supported.
12	**The site or application structure is clear, easily understood and addresses common user goals** For example, gathering information, submitting data, carrying out research. Users should be able to work out where they need to go to carry out common user goals and be able to quickly gain an understanding of how the site or application is structured.
13	**Links are clear, descriptive and well labelled** Links should be clearly 'clickable' (e.g. underlined or colourised) and it should be clear to users where any given link goes to. Non-descriptive links such as 'click here' should be avoided and any links going to an external website or opening a new window should be identified as such.

14	**Browser standard functions (e.g. 'back', 'forward', 'bookmark') are supported** Users should be able to bookmark a page (or be presented with a URL to use) and go back and forth without breaking the site or losing any information they have entered.
15	**The current location is clearly indicated (e.g. breadcrumb, highlighted menu item)** Users should always know where they are in the site or application.
16	**Users can easily get back to the homepage or a relevant start point** For example, a homepage link might be part of the breadcrumb or a home link might be available as part of the header.
17	**A clear and well structure site map or index is provided (where necessary)** The sitemap might be part of the header or footer and should ideally be available from every page on the site.

Control & feedback

18	**Prompt and appropriate feedback is given** For example, a confirmation message is shown following a successful transaction, input errors are promptly highlighted and it's made clear to users when a page has been updated.
19	**Users can easily undo, go back and change, or cancel actions** If an action can not be undo then users should at least be given the chance to confirm an action before committing (e.g. before placing an order). For example, users can return to a step and change their options or dynamically change a value without having to start again. Where an action can't be undone (e.g. a deletion), this should be made clear to users.
20	**Users can easily give feedback** For example, via email or an online feedback / contact us form. There should be an indication of how long users can expect to wait for a response if a query has been made.

Errors

21	**Errors are clear, easily identified and appear in appropriate locations** Errors should be immediately apparent to users and ideally be located close to the offending input or function (e.g. adjacent to an input entry field). Inputs causing an error should be highlighted, together with an explanation for the error.
22	**Error messages are concise, written in easy to understand language and describe what's occurred and what action is necessary** Errors should avoid using very technical terms or jargon and should be written from the user's perspective.
23	**Common user errors have been taken into consideration and where possible prevented** Common user errors might be missing fields, invalid formats and invalid selections. For example, fields might limit input to particular a format (e.g. numbers only) or only become available once certain criteria have been met. JavaScript might also be utilised to provide immediate feedback for common formatting errors or errors caused by missing fields.
24	**Users are able to easily recover (i.e. not have to start again) from errors** For example, users might be able to re-edit and resubmit a form or enter a different value.

Content & text

25	**Content available (e.g. text, images, video, audio) is appropriate and sufficiently relevant, and detailed to meet user goals** Content should also be appropriately formatted, so for example videos and audio should be directly playable (i.e. shouldn't need to be downloaded to be played) and images should be of a sufficient quality.
26	**Links to other useful and relevant content (e.g. related pages, external websites or documents) are available and shown in context** For example there might be links from an article to related articles, related content or related external websites.
27	**Language, terminology and tone used is appropriate and readily understood by the target audience** Jargon should be kept to a minimum and plain language should be used where ever possible.

28	**Terms, language and tone used are consistent (e.g. the same term is used throughout)** Capitalisation (e.g. 'Main title'; 'Main Title'; 'MAIN TITLE') and grammar should be consistent, together with the use of formal or informal terms (e.g. could not vs couldn't; what's vs what is etc...).
29	**Text and content is legible and scanable, with good typography and visual contrast** Users should be able to quickly scan headers and body text, in order to get an overview of what's available.

Help

30	**Online help is provided and is suitable for the user base** Help should be written in easy to understand language and only uses recognised terms. Users should be able to easily find and access help and where appropriate contextual help should be available, such as help for a specific page, feature or process.
31	**Online help is concise, easy to read and written in easy to understand language** Help should cover the essentials without providing excessive detail and shouldn't use jargon or technical terminology that isn't likely to be understood by users.
32	**Accessing online help does not impede users** Users should be able to resume work where they left off after accessing help. Ideally help should be available directly on a page or using a new window. If help is provided in the form of a document, it should be formatted for the web (e.g. PDF, rather than a Word document).
33	**Users can easily get further help (e.g. telephone or email address)** If a telephone help number is provided the hours of operation should be shown. If an email address or online form is provided, an indication should be given of how long a response is likely to take (e.g. within the next 24 hrs).

Performance

34	**Site or application performance doesn't inhibit the user experience (e.g. slow page downloads, long delays)** Web page downloads shouldn't take longer than 5 seconds and on page interactions (e.g. using an application or AJAX functionality) shouldn't take any longer than 1 second to respond. Interactions taking longer than 1 second to respond should provide suitable feedback to show that something is taking place (e.g. an hour glass or swirling graphic).
35	**Errors and reliability issues don't inhibit the user experience** Sites and applications should be free of bugs and shouldn't have any broken links.
36	**Possible user configurations (e.g. browsers, resolutions, computer specs) are supported** Websites should should work with the most common browsers. Applications should be usable with common computer specifications (operation system, memory, available disk space) and screen resolutions.

Energy-related

37	**Energy feedback is understandable by everyone without expert knowledge**
38	**Energy feedback is useful for making wise decisions on own energy use**
39	**Energy feedback helps users to understand which devices/systems consume a largest part of energy (e.g. comparing the consumptions of appliances)**
40	**Feedback has a connection to individual actions, for example, providing features to support the discovery of patterns and exceptions based on uses and habits.**
41	**Energy feedback informs users of energy waste, not just show kWh, CO2 or cost**

The expert reviewer analyses how well the tool (the parts of the tool that are chosen for analysis) meets the guidelines and gives separate scores (very poor, poor, moderate, good, excellent, N/A) related to the guidelines. Guidelines that are not relevant for the tool under the review can be skipped (by marking N/A in Excel cell).

The Excel template calculates the overall usability score (out of 100). However, the value is not the most important output of the expert review, but we are more interested in usability problems found and comments given. The work can be performed without the Excel template if it is not found useful for analysing.

The most important usability problems can be found by a small number of expert reviewers, even by one expert of usability.

3.3 User tests

The basic idea of the user tests is that potential users are recruited to try the use the prototype and give feedback. The test users perform a set of specified tasks that are planned beforehand. The test users are asked to think aloud while performing the tasks, i.e. the purpose is to get an idea what the user is thinking while performing the tasks.

Observers take notes of what test users say without attempting interpreting. The user tests can be video/audio recorded if users give permission for that.

Task completing rates and time consumed can be recorded if this information is considered relevant. Usability problems found are presented together with problem severity classification.

User tests may involve an interview or questionnaire before and/or after the test. A simple questionnaire could ask for relevant background data of the test user and feedback given based on the user tests.

Most of the usability problems are found with a small number of test users (Figure 1). Rather than running the tests with 10 users it is better to do the tests twice with five test users, i.e. after fixing the usability problems new tests are performed with five different users.

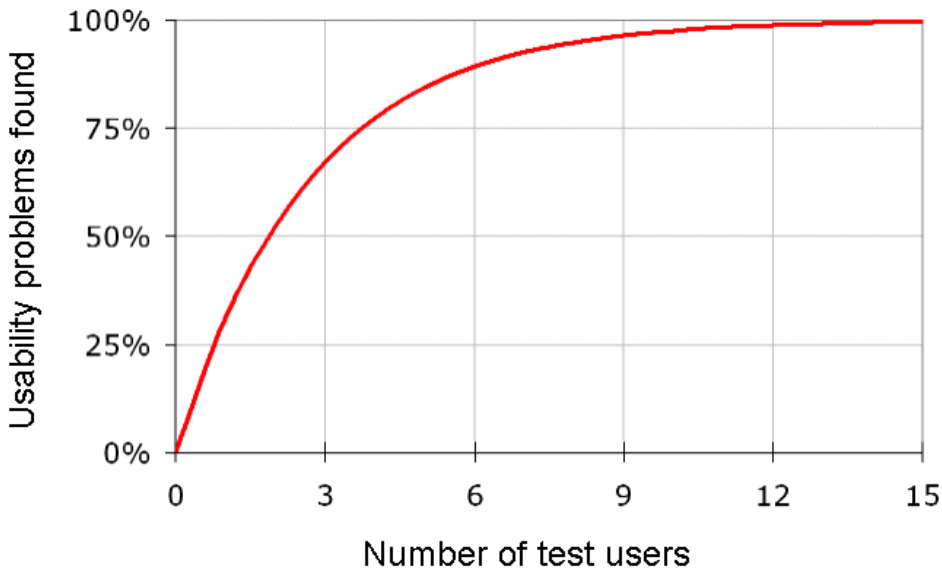


Figure 1. Optimal number of test users in user test is around 4-6 (Nielsen 2000)

3.4 Templates

These templates are provided to make the work easier and straight-forward to perform. The templates originate from public sources and were partly modified for our purpose. The templates can be downloaded from the collaboration platform.

Table 3. Templates for performing the work

template-EXPERT-REVIEW-TOOL-X.xls	Excel-template for performing the expert reviews. • Fill only columns D (score) and I (comments). • The Excel template calculates the overall usability score (out of 100). However, the value is *not* the most important output of the expert review, but **we are more interested in usability problems found and comments given,** i.e. t is not necessary to fill the scores. • Expert reviews can be performed without this template. **The heuristics are also presented in Section 3.2 of this document.**
template-USER-TEST-PLAN-TOOL-X.docx	Word-template for planning the user tests. • The template gives an example of a typical plan. • You may want your tests to be more or less similar keeping in mind that the goal is to find the most severe usability problems.
template-QUESTIONNAIRE.docx	Word-template for a short questionnaire (performed as a part of user test) • You may add more questions if needed
template-USER-TEST-RESULTS-TOOL-X.docx	Word-template for presenting the results of the user tests • For more detailed presentation of results that is possible in the deliverable

4. Usability study of Energy Brokering Tool (first stage)

4.1 Description of the tool

An early prototype (May 2014) of energy brokering tool was studied in this stage of the work. The study concentrated in the usability evaluation of the environment in which the tool will be developed (Figure 2). The tests were performed using a PC (laptop).

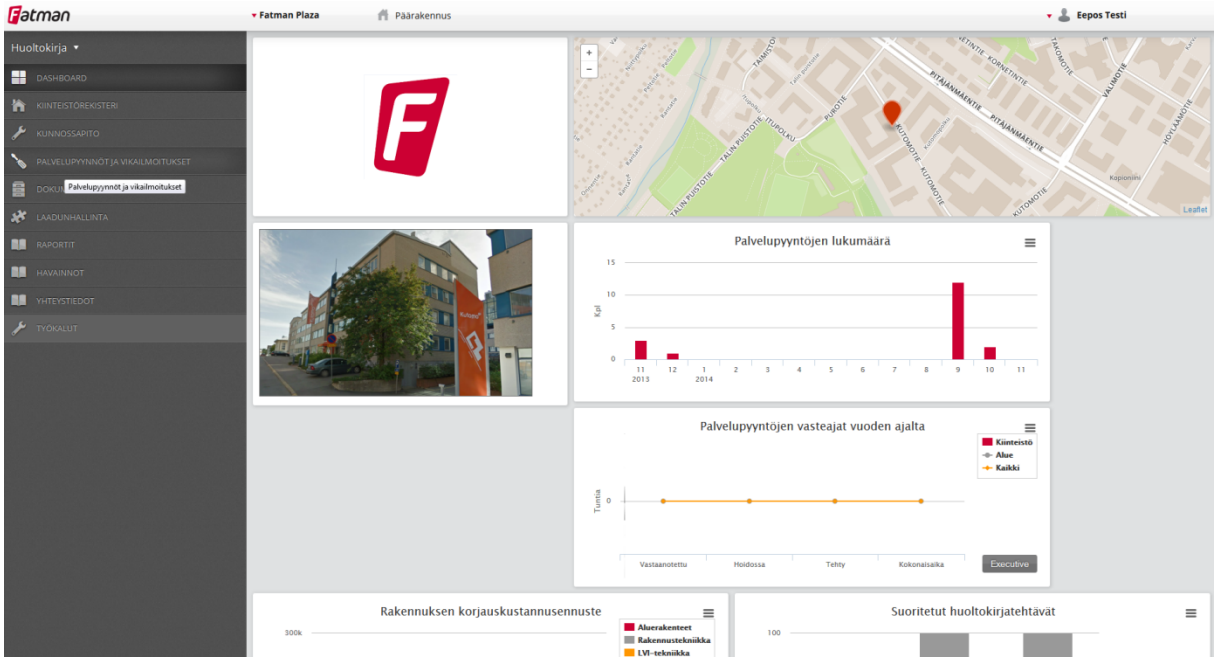


Figure 2. A screenshot from an early prototype of energy brokering

4.2 Methods

4.2.1 Expert reviews

An expert of usability evaluated the tool using the methodology described in 3.2.

4.2.2 User tests

The test users were given tasks which they tried to accomplish. The completion rates were recorded. The test users were asked to think aloud while performing the tasks, i.e. the purpose is to get an idea what they were thinking while performing the tasks. Observers took detailed notes during the tests. Verbal feedback given by the test users was written down. In addition, a short questionnaire was performed after the test.

User tests were performed with four participants. Test participants attempted completion of the following tasks:

1. Create a new notice of defect

2. Create a new ”observation” into the service manual

3a. Create a new maintenance document

3b. Open this document

4. Check all the maintenance tasks for the period from 2014 to 2020 and move one of the tasks to another year.

The characteristics of the test users are presented in Table 3.

Table 4. Characteristics of the test users

- **Working field**

Facility management	4
Other	0
Other	0
Total	**4**

- **Education**

Education background in technology	4
Other	0
-	0
Total	**4**

- **Age**

18-25	0
26-39	2
40-59	2
60-74	0
Total	**4**

- **Gender**

Female	1
Male	3
Total	**4**

4.3 Findings in expert reviews

The expert review concentrated on evaluating the main view of the tool and no tasks similar to those in user tests were performed. The following findings were made:

- The general structure is clear.
- It is not necessarily clear what do “Fatman Plaza” and “Päärakennus” mean. Should there be "Valitse kiinteistö"?
- “Takaisin tuotevalintaan” sounds too technical, a suggestion; “Alkuun" or "Takaisin alkuun"
- A lot of figures are shown in the main view. Not all are relevant. Can the user choose the most relevant for own work?

4.4 Findings in user tests

- General logic works well and is clear.
- Most of the test users were able to complete most of the tasks (Table 4), either instantly or after a couple of attempts.

- The most significant problem was found in choosing the building and in understanding the logic of “kiinteistö” (a block of several buildings) and building. Almost all of the test users received the same error message: ”Havaintoja voi tehdä vain rakennustasolle”.
- Some of the error messages were shown too quickly, so that the test users were not able to read or even notice them. In these cases the test users were not aware what happened, and they did not know whether the information they sent was accepted or not by the tool. The error messages should be presented more clearly. It is probably a good idea to include “ok” button to which user have to press to continue.
- If an attachment is obligatory when submitting information, this should be presented clearly.
- There is a different kind of logic in submitting “notice of defect” (vikailmoitus) and ”observation” (havainto). In the first case, a form is shown while in the second case the user have to locate and press Add button (”Lisää”) in the right upper corner.
- One of test users noted that he wants to submit more information (e.g. contract person, how to get in the building etc.) when giving a notice a defect.
- None of the test users had a problem is moving a maintenance tasks to another year (task 4).

Table 5. The completion rates of the tasks. A total number of users was four.

Task	**Number of test users able to complete the task**
1. Create a new notice of defect	4
2. Create a new ”observation” into the service manual	1
3. Create a new maintenance document. Open this document	4*
4. Check all the maintenance tasks for the period from 2014 to 2020 and move one of the tasks.	4

* but all of them were only partly successful

Table 6. Results of the questionnaire performed after using the tool. X:s show the number of responses.

	Strongly disagree				**Strongly agree**
	1	2	3	4	5
1. I think that I would like to use this system frequently			X	X	XX
2. I found the system unnecessarily complex		XX	X	X	
3. I thought the system was easy to use				XXXX	
4. I think that I would need the support of a technical person to be able to use this system	XX		X		X
5. I found the various functions in this system were well integrated		X	X	X	X
6. I thought there was too much inconsistency in this system	X		XX		
7. I would imagine that most people would learn to use this system very quickly			X	XX	X
8. I found the system very cumbersome to use	X	XXX			
9. I felt very confident using the system			X	XX	X
10. I needed to learn a lot of things before I could get going with this system	XXX			X	

4.5 Conclusion: major findings and recommendations

The recommended changes and justifications are driven by the results of both expert reviews and user tests including comments given the participants of the user tests. Each recommendation is presented together with a severity rating. Table 6 shows only the most significant and severe problems found.

Table 7. Recommendations based on usability study

Recommendation (what to change)	**Justification (why)**	**Severity (high/moderate/low)**
Make it easier for user to understand the logic of “kiinteistö” (a block of several buildings) and building and choosing them.	The most significant problem was found in choosing the building and in understanding the logic of “kiinteistö” (a block of several buildings) and building. Almost all of the test users received the same error message: ”Havaintoja voi tehdä vain rakennustasolle”.	high
The error messages should be presented more clearly. It is probably a good idea to include “ok” button to which user have to press to continue.	Some of the error messages were shown too quickly, so that the test users were not able to read or even notice them. In these cases the test users were not aware what happened, and they did not know whether the information they sent was accepted.	high
Aim for consistency.	There is a different kind of logic in submitting “notice of defect” (vikailmoitus) and ”observation” (havainto). In the first case, a form is shown while in the second case the user have to locate and press Add button (”Lisää”) in the right upper corner.	moderate

5. Usability study of Energy Brokering Tool (second stage)

5.1 Description of the tool

A prototype of energy brokering tool (March 2015) was studied in this stage of the work. The tool under the study had several characteristics not available in the earlier version of the prototype (4.1). With the tool the users are, for example, able to monitor energy consumption, add new consumption values and new energy meters to the system. Figures 3-7 show screenshots of the user interface. The language of the tool is Finnish. The tests were performed using a PC (laptop).

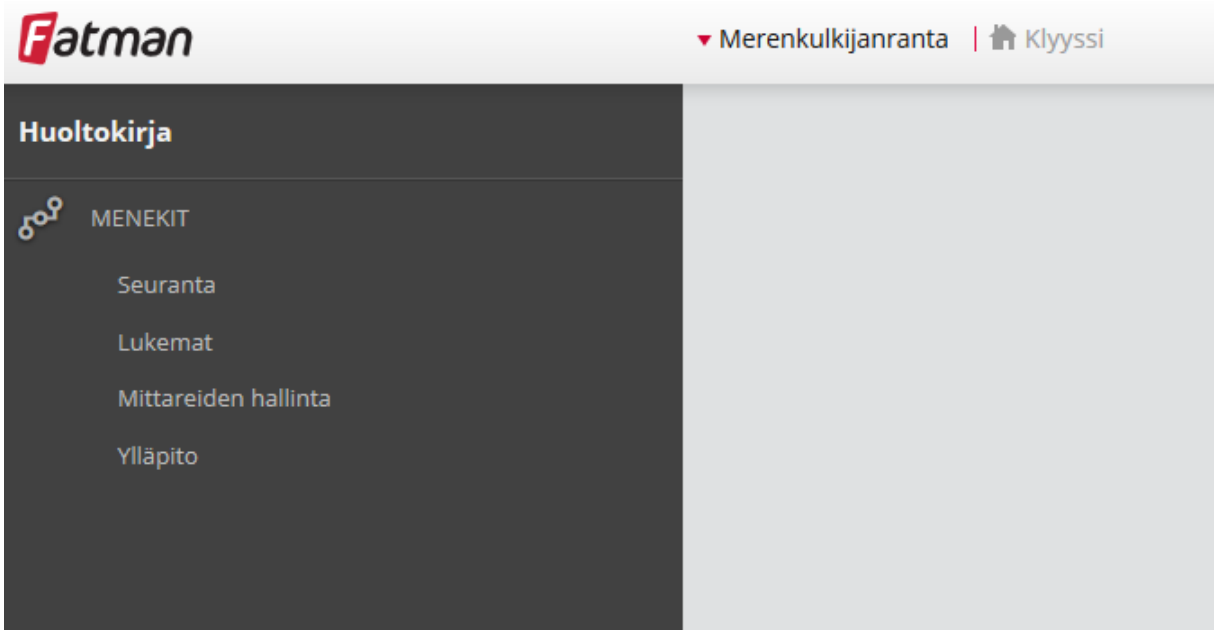


Figure 3. Screenshot 1 from a prototype of energy brokering

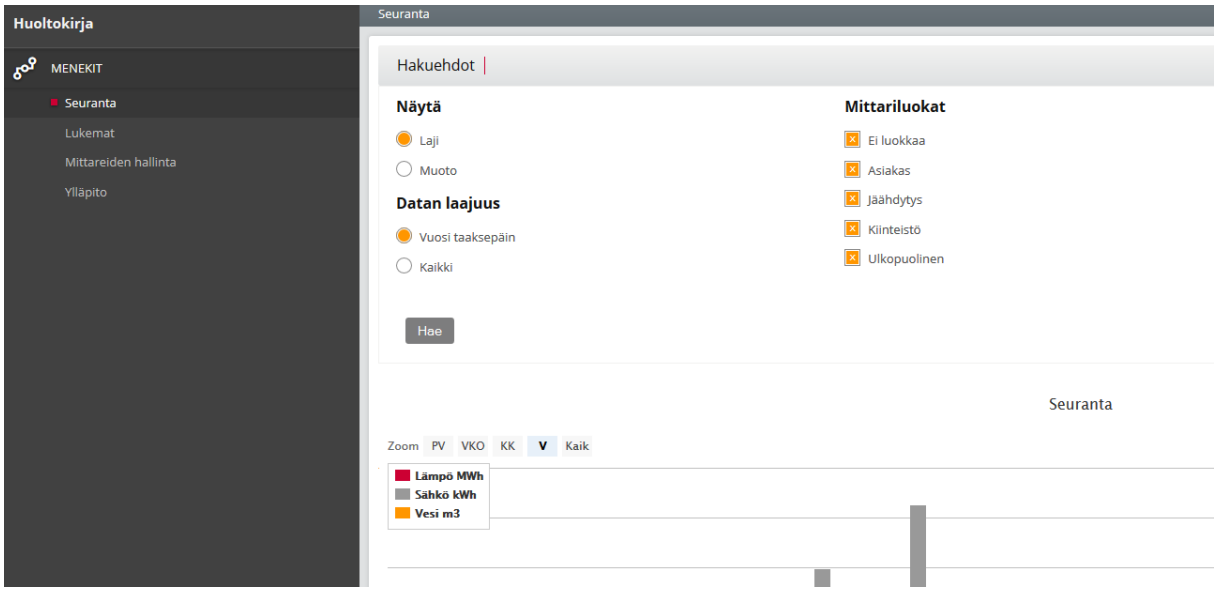


Figure 4. Screenshot 2 from a prototype of energy brokering

Figure 5. Screenshot 3 from a prototype of energy brokering

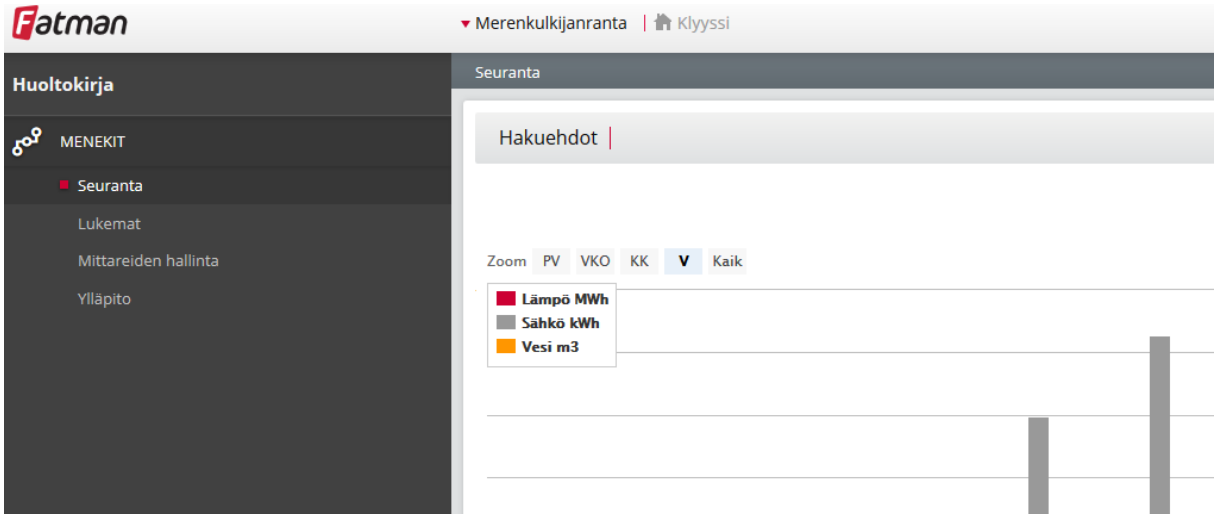


Figure 6. Screenshot 4 from a prototype of energy brokering

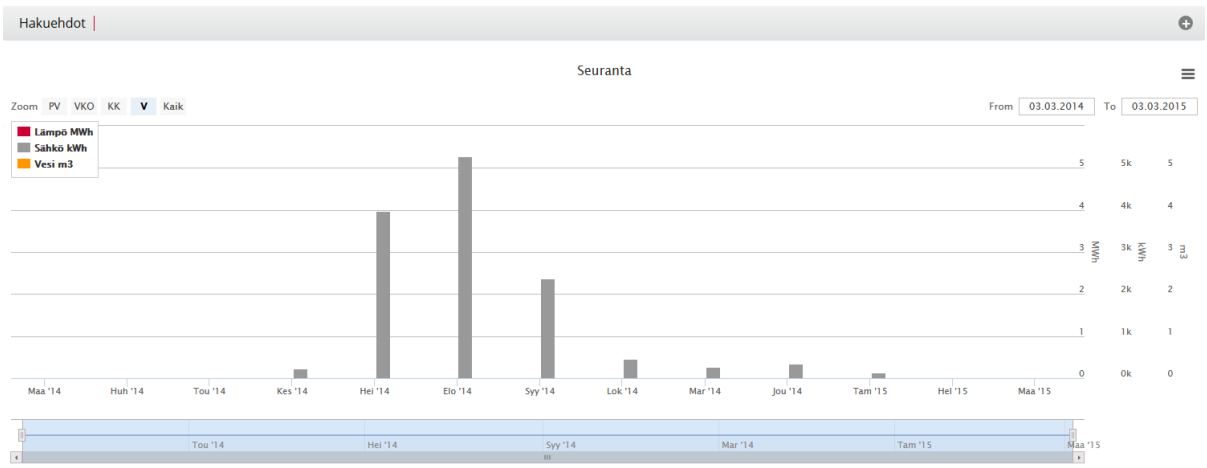


Figure 7. Screenshot 5 from a prototype of energy brokering

5.2 Methods

5.2.1 Expert reviews

One expert of usability evaluated the tool using the methodology described in 3.2.

5.2.2 User tests

The test users were given tasks which they tried to accomplish. The completion rates were recorded. The test users were asked to think aloud while performing the tasks, i.e. the purpose is to get an idea what they were thinking while performing the tasks. Observers took detailed notes during the tests. Verbal feedback given by the test users was written down. In addition, a short questionnaire was performed after the test.

User tests were performed with eight participants. Test participants attempted completion of the following tasks:

1. Find out what was the heat energy consumption in September 2014 in the Klyyssi premises?
2. Submit a new measurement value of today to the system: add a value of 30 kWh for the district heating energy meter number 101.
3. Add a new meter for district heating.

The characteristics of the test users are presented in Table 7. All the test users were first time users, i.e. none of the test users has earlier used this or other software tools of Fatman. The education level of the test users was lower than in the first stage tests (presented in Chapter 4).

Table 8. Characteristics of the test users

- **User group**

Serviceman (title in Finnish: huoltomies/-asentaja)	6
Service manager (title in Finnish: huoltopäällkkö)	2
-	o
Total	**8**

- **Education level / Computer use experience**

Education background in technology or a related field	8
-	0
-	0
Total	**8**

- **Age**

18-25	3
26-39	2
40-59	3
60-74	0
Total	**8**

- **Gender**

Female	0
Male	8
Total	**8**

5.3 Findings in expert reviews

The following findings were made in the expert review:

- The tool seems to generally easy to use but see the comments below.
- The hierarchy of navigation and terminology used seem not be as logical as possible.
- The term “Menekit” seems to be quite strange to me used as it is here.
- There is a lot options for making search for consumption data, not all of the options are understandable (Figure 4). It is not clear for me what “Näytä: Laji/Muoto” mean here.
- The users may found problematic to return back after a search (if not yet learned how to operate with the search – it is quite simple when you have realized how it works).
- The bar chart has several Y-scales (Figure 7). It took some time to find out to which each scale is related. Colour symbols could be used to make it clear. The values are shown when mouse is over the chart which is nice and useful.
- Some suggestions for terminology (sorry, in Finnish only, not possible/easy to translate all these accurately into English; the idea of the suggestions is to improve the terminology so that is describes the contents as clearly as possible):
    - Menekit => Energia ja vesi [Menekit tuntuu viittaavan enemmän kappaletavaran kulutukseen]
    - Seuranta => Kulutusseuranta [tarkennus lienee paikallaan]
    - Lukemat => Lukemien syöttö [monet etsivät kulutusarvoja lukemista]
    - Mittareiden hallinta => Mittareiden hallinta [tämä siis ok, eikä ehdoteta muutosta]
    - Ylläpito => Näyttöyksilöt [jos ei sisällä muuta]

5.4 Findings in user tests

The most important findings are presented in Table 8 and the results of the questionnaire are presented in Table 9.

Table 9. The main problems encountered in performing the tasks of the user tests. The number of test users was eight.

Task	Main problems encountered and other findings
1. Find out what was the heat energy consumption in September 2014 in the Klyyssi premises?	The task was *not* found to be easy to solve. Only one of the test users performed the task straightforwardly. About half of the test users spent considerable time in navigating; some of them were finally successful. Several others were not able to perform the task successfully. Most test users spent a lot time in navigation and could not locate information on energy consumption. They did not notice that information even they visited that section of the software. A reason for that is that a large number of search options are shown above the bar chart (Figure 4) carrying the consumption data. On a small monitor (a laptop was used in the tests) the user has to scroll down to see the whole chart. Many of the test users did not understand the terminology correctly (Seuranta, Lukemat) but tried to locate consumption data under Lukemat (which is available only for importing new consumption values). Some of the test users had problems in understanding the bar chart (e.g. could not locate the correct month).
2. Submit a new measurement value of today to the system: add a value of 30 kWh for the district heating energy meter number 101.	The task was found to be easy to perform. The test users found it easy to locate where to add new consumption data. However, not all of them noticed Tallenna (Save) button. They tried to locate the button in the lower section of the screen where buttons typically are. Many of them tried to save the new information by pressing enter button. Tallenna button is located near the upper right corner which is not the most natural location to find it for the first time user. The colour of button changes to red when values are written which makes the button easier to locate but still not all found it.
3. Add a new meter for district heating.	The test users did not find it problematic to add a new meter but many of them accidentally created the new meter over an existing one. They did not even realize they replaced an existing meter. The problem occurred because they did not realize the Lisää (Add) button that is located near the upper right corner.

Table 10. Results of the questionnaire performed after using the tool. X:s show the number of responses.

	Strongly disagree				**Strongly agree**
	1	2	3	4	5
1. I think that I would like to use this system frequently			xxx	xxxx	x
2. I found the system unnecessarily complex	x	xxxxx	x	x	
3. I thought the system was easy to use			xxx	xxxxx	
4. I think that I would need the support of a technical person to be able to use this system	x	xxx	xx	x	x
5. I found the various functions in this system were well integrated			xx	xxxxx	x
6. I thought there was too much inconsistency in this system		xxxxxx	x	x	
7. I would imagine that most people would learn to use this system very quickly			xx	xxx	xxx
8. I found the system very cumbersome to use	x	xxx	xx	x	
9. I felt very confident using the system		x	xxxx	xxxx	
10. I needed to learn a lot of things before I could get going with this system	xx	xxxx	xx		

5.5 Conclusion: major findings and recommendations

The recommended changes and justifications are driven by the results of both expert reviews and user tests. Table 10 shows the most significant and severe problems.

Table 11. Recommendations based on usability study

Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Make terminology as clear as possible. Some suggestions: Menekit => Energia ja vesi [Menekit tuntuu viittaavan enemmän kappaletavaran kulutukseen] Seuranta => Kulutusseuranta [tarkennus lienee paikallaan] Lukemat => Lukemien syöttö [monet etsivät kulutusarvoja lukemista] Mittareiden hallinta => Mittareiden hallinta [tämä siis ok, eikä ehdoteta muutosta] Ylläpito => Näyttöyksilöt [jos ei sisällä muuta]	The test users had problems in navigation and especially in finding measurements of energy consumption.	moderate
Some (textual) advice is needed to find Tallenna (Save) and Lisää (Add) buttons. Short advice texts should be added if it is not possible to move the buttons from the upper right corner (the test users supposed to find such buttons in the low right corner).	Many of the test users did not notice Tallenna (Save) and Lisää (Add) buttons and could not perform the tasks successfully.	moderate
Make the search options simpler. Are all the options really needed? And make the texts more understandable, e.g. it is not clear what “Näytä: Laji/Muoto” means.	Many of the test users spent a lot of time in reading the search options and could not locate the bar chart below,	moderate

6. USABILITY STUDY OF BIMZONE

6.1 Description of the tool

BimZone is a tool for presenting room specific data visually in real time. It brings together building information model (BIM) and measurements of building automation system (BAS). BimZone is developed a as part of Task 3.3.

BimZone is capable of presenting various data. The version under the usability study visualizes room temperature in different parts of the building (Figure 8). 3D model is rotating and can be stopped or turned by the user. The user can choose the time period and several temperature related options (Figure 9).

A working prototype (date of version: 5th May 2014) of BimZone was evaluated in this work (modelled building used in the tests was Merenkulkijanranta/Klyysi). The tests were performed using a PC.

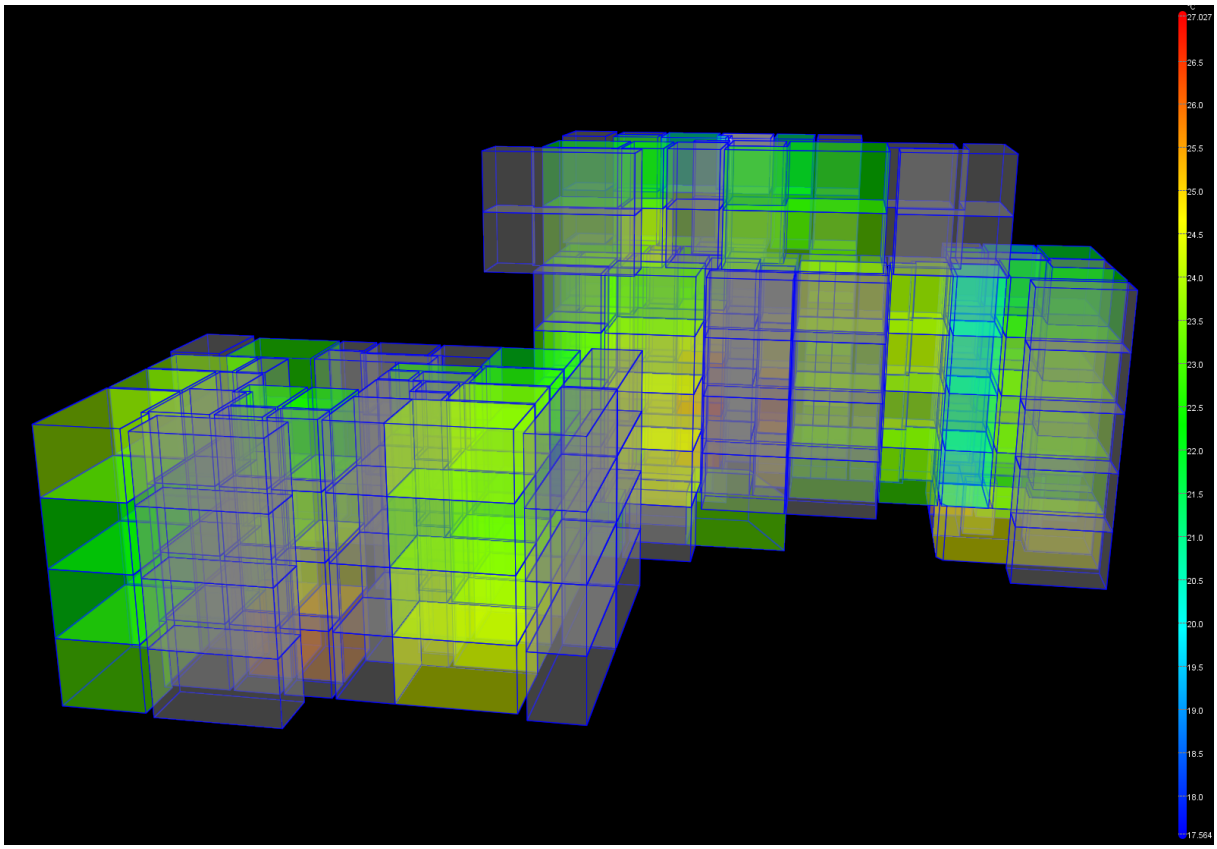


Figure 8. BimZone gives a visual illustration of room temperatures in different rooms of the building

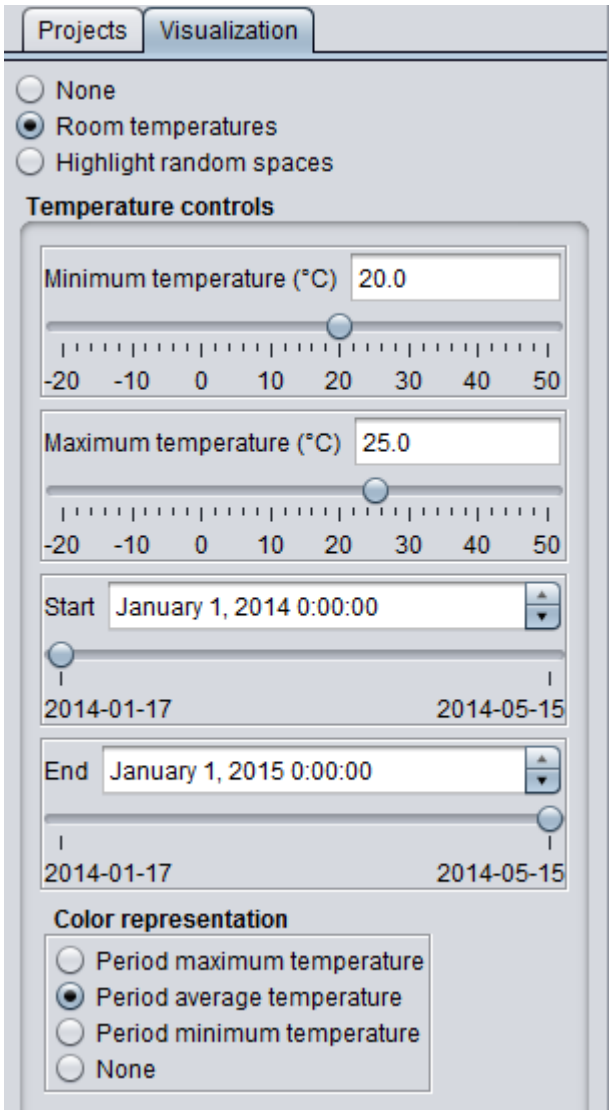


Figure 9. BimZone gives user a possibility to choose the time period and gives options for presenting room temperatures

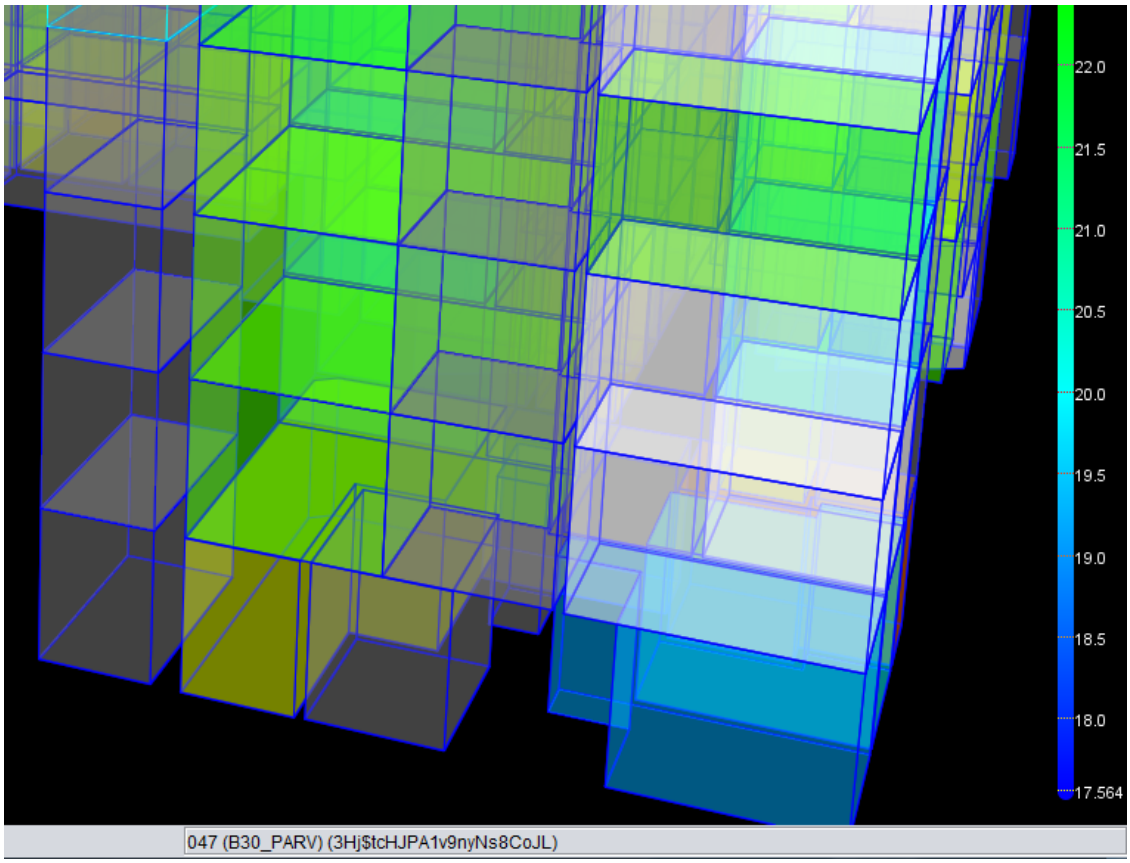


Figure 10. Information given by BimZone.

6.2 Methods

6.2.1 Expert reviews

One expert of usability evaluated the tool using the methodology described in 3.2.

6.2.2 User tests

User tests were performed with five participants. Test participants attempted completion of the following tasks:

1. What is the room temperature in warmest room?
2. What is the room temperature in coldest room?
3. What is the name of the room which is coldest?
4. Can you stop the 3D motel from rotating?
5. Can you make the 3D motel to rotate again?

The characteristics of the test users are presented in Table 11.

Table 12. Characteristics of the test users

- **Working field**

Facility management	4
Software company developing tools for facility management	1
Other	0
Total	**5**

- **Education**

Education background in technology	5
Other	0
-	0
Total	**5**

- **Age**

18-25	0
26-39	3
40-59	2
60-74	0
Total	**5**

- **Gender**

Female	1
Male	4
Total	**5**

The test users were given tasks which they tried to accomplish. The completion rates were recorded. The test users were asked to think aloud while performing the tasks, i.e. the purpose is to get an idea what they were thinking while performing the tasks. Observers took detailed notes during the tests. Verbal feedback given by the test users was written down during and after the tests.

6.3 Findings in expert reviews

The following findings were made in the expert review.

General comments

- Very attractive way of presenting information!
- Name of the building could be shown somewhere in the visualization view.
- Temperature values in Y-axis are quite small. A larger font would be more readable.

Navigation

- Sometimes the whole 3D model is lost in the low right corner when maximized.
- The 3D is rotating by default. It took me some time to learn how to stop it and how to continue the rotation. Own buttons (stop, rotate) for the purpose could be useful. At least there should be an easy way to stop the rotation since it starts to disturb after a while.

Controls

- Redesign is suggested for certain parts of the controls, see the following comments.
- The colours in 3D modes update slowly which makes a problem in using the controls. Consider adding an Update button, i.e. update the 3D model only after the button is

pressed. At least first update the new position in the slide control and then update the visualization.

- Simplify the options and use shortcuts. I did not fully understand what does Minimum and Maximum temperature mean.
- Shortcuts should be created for the important information, e.g. lowest and highest temperatures (now, yesterday, during the last week)
- The two time scales are always not in sync, are both the scales needed?
- There is a problem in using the slide control Contrast because 3D modes updates continuously and slowly. Is slide control needed for the purpose since there is probably no need to adjust contrast accurately?

Terminology

- A suggestion for the order and terminology
    - Minimum temperature during period
    - Average temperature during period
    - Maximum temperature during period

Other

- The name of the room is shown using a small font in the lower information panel, consider presenting this more clearly. At least the code after that should be removed.
- Could it be possible to get more information on the selected rooms? The users may be interested in temperature trends (a link to an interactive figure?).

6.4 Findings in user tests

The principal findings made in user tests:

- Graphical presentation was understood instantly and was found to be attractive.
- More than half of the test users could not find the name of the rooms (presented in the lower information panel with a small font).
- The rotation of the 3D model starts to disturb after a while. Most of the test users were able to stop the rotation of the 3D model but cannot make it rotate again,
- Not all were able to manually rotate the 3D model.
- The settings in the left column (Figure 9) were not understood well. When testing the settings the users performed a number of actions before the result of the first action was realized.
- Sometimes the 3D model is lost as it goes invisible in the low right corner of the window.
- It was considered to be problematic to reach the zones inside the building.

6.5 Conclusion: major findings and recommendations

BimZone presents room temperatures in a way that was found attractive and easy to understand. The suggestions to improve the usability are the following.

Table 13. Recommendations based on usability study

Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Redesign of controls is suggested. A simpler way to choose the settings is needed. (See above the findings made.)	The purpose of "Minimum temperature" and "Maximum temperature" was not understood. The two time scales are always not in sync - are both the scales needed?	high
Consider adding an update button; i.e. uploaded data is downloaded only after the user has changed all the settings and pressed update button.	The data updates quite slowly (depending on the internet connection) and users may perform a number of actions before the result of the first action is realized.	moderate
Present the name of the selected room more clearly (in a way or another). Remove the machine language code after the name of the room (Figure 10).	More than half of the test users could not find the name of the rooms that is shown in the lower information panel using a small font.	moderate
Create shortcuts for presenting the important information, e.g. lowest and highest temperatures (now, yesterday, during the last week)	It is probable that the users have simple tasks to perform with the tool and want to perform the tasks easily and rapidly.	high
Increase font size of temperature values in Y-axis	Temperature values in Y-axis are quite small. A larger font would be more readable.	low
There should be an easy way to stop the rotation of 3D model.	The 3D model is rotating by default. The rotation starts to disturb after a while.	moderate

7. Usability study of Energy Performance Monitoring Tool (UnityMerenkulkijanranta) (first stage)

7.1 Description of the tool

The UnityMerenkulkijanranta is a tool that gives a 3D model of buildings constructed (partly still under construction) in Lauttasaari, Helsinki.

UnityMerenkulkijanranta uses Unity gaming engine for presenting the buildings. During the first stage of usability study (May 2014) UnityMerenkulkijanranta is in an early development phase. The environments are not modelled fully realistically.

The user can travel in the area by use arrow tools and the mouse.

The tests were performed using a PC.

Figure 11. An overview of UnityMerenkulkijanranta

Figure 12. A detail of UnityMerenkulkijanranta

7.2 Methods

7.2.1 Expert reviews

One expert of usability evaluated the tool using the methodology described in 3.2.

7.2.2 User tests

User tests were performed with five participants who were asked to attempt to navigate to the inner court.

The characteristics of the test users are presented in Table 13.

Table 14. Characteristics of the test users

- **Working field**

Facility management	4
Software company developing tools for facility management	1
Other	0
Total	**5**

- **Education**

Education background in technology	5
Other	0
-	0
Total	**5**

-
- **Age**

18-25	0
26-39	3
40-59	2
60-74	0
Total	**5**

-
- **Gender**

Female	1
Male	4
Total	**5**

The test users were given tasks which they tried to accomplish. The completion rates were recorded. The test users were asked to think aloud while performing the tasks, i.e. the purpose is to get an idea what they were thinking while performing the tasks. Observers took detailed notes during the tests. Verbal feedback given by the test users was also written down.

7.3 Findings in expert reviews

The following findings were made in the expert review.

General

- Although this is a working prototype in which surroundings are not modelled realistically, it shows well that the buildings are located by the sea.
- In this version there is not much “content” – all one can do is to navigate in the area.

Navigation

- I found that navigation is performed by arrow keys and mouse. Is it possible to use only one of these, i.e. mouse or arrows? Are there any keyboard shortcut keys that I as a user do not know. If there are such keys an advice for using them is needed.
- The arrows work as supposed.
- The mouse acts very sensitively, i.e. small movement of the mouse turns the view greatly. I would consider making the movement less sensitive.
- Double-click of the mouse has no effect. I would suppose that double-click moves to the chosen direction.
- It is possible to navigate through the wall which is unrealistic.
- The Unity Web Player seems not to have been designed for multitasking, i.e. using mouse in another application turns the view in Unity.
- Full screen cannot be activated from web browser (Firefox) but is activated from the right click menu of Unity. This seems to be a characteristic of the Unity Web Player.

7.4 Findings in user tests

The following notes were made during the user tests (five individual users):

- Most of the test users were instantly able to navigate but not everyone noticed to use the arrow keys
- The movement of mouse moves the view rapidly but the effect of arrow keys is smaller and reminds of walking
- The similarity with gaming environments was understood. Some of the test users were able to use the shortcuts, e.g. jump, and were able to use the tool fluently. Some of the test users asked where the gun is.
- Some of the test users wanted to go to the upper floor.
- The purpose of the tool was not clear yet for the users. One of the test users suggested using the tool for visualising the views from the windows of apartments, i.e. the tool could be useful for real estate agents who sell apartments still under construction.

7.5 Conclusion: major findings and recommendations

Table 15. Recommendations based on usability study

Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
The tool needs more content (this is natural since the tool under the study was still in an early development phase).	The purpose of the tool is not clear yet for the users.	high
Consider making the mouse less sensitive to the movement	The mouse works very sensitively (at least for those who are not familiar with gaming environments)	moderate
Give guidance for the shortcuts	Those who are familiar with similar gaming environment used shortcuts that were not known by the others	moderate
Give a possibility to leave the ground level and to go the upper floors	Adds sense of natural movement	moderate
Consider removing the possibility to navigate through walls	Adds sense of natural movement	low

8. Usability study of Energy Performance Monitoring Tool (UnityMerenkulkijanranta) (second stage)

8.1 Description of the tool

A new version of UnityMerenkulkijanranta was studied by usability tests. This version was improved from the earlier tested version in two main respects: the 3D visualization of the buildings and the area were more detailed and realistic, and several applications were implemented. The applications are, for example, able visualize energy consumption (Figure 14) and alarms (Figure 15). The navigation works similarly than in the earlier version of the tool.

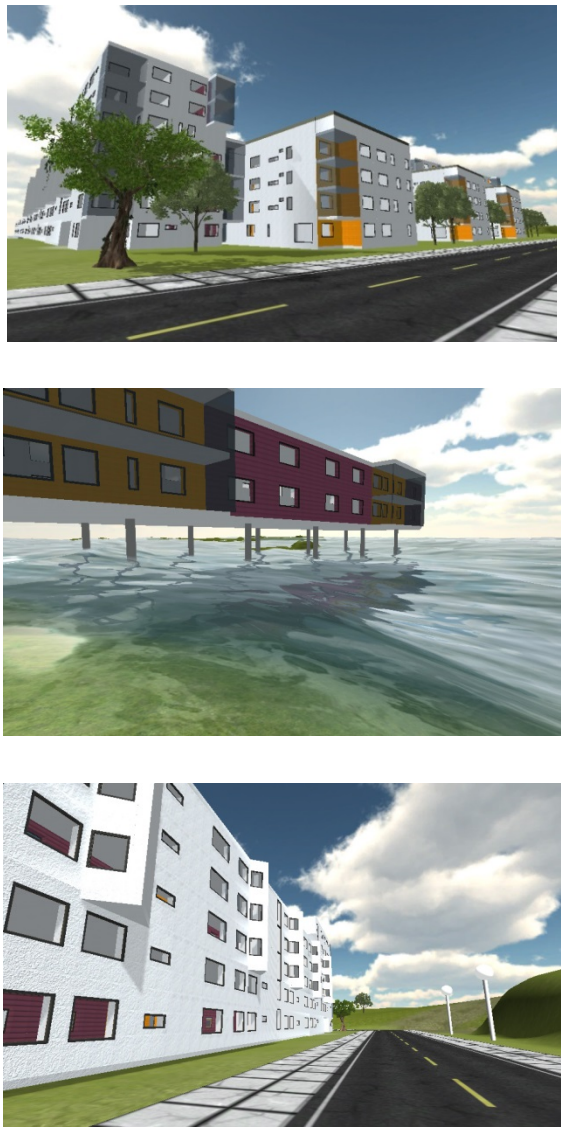


Figure 13. Walking in the 3D neighbourhood model.

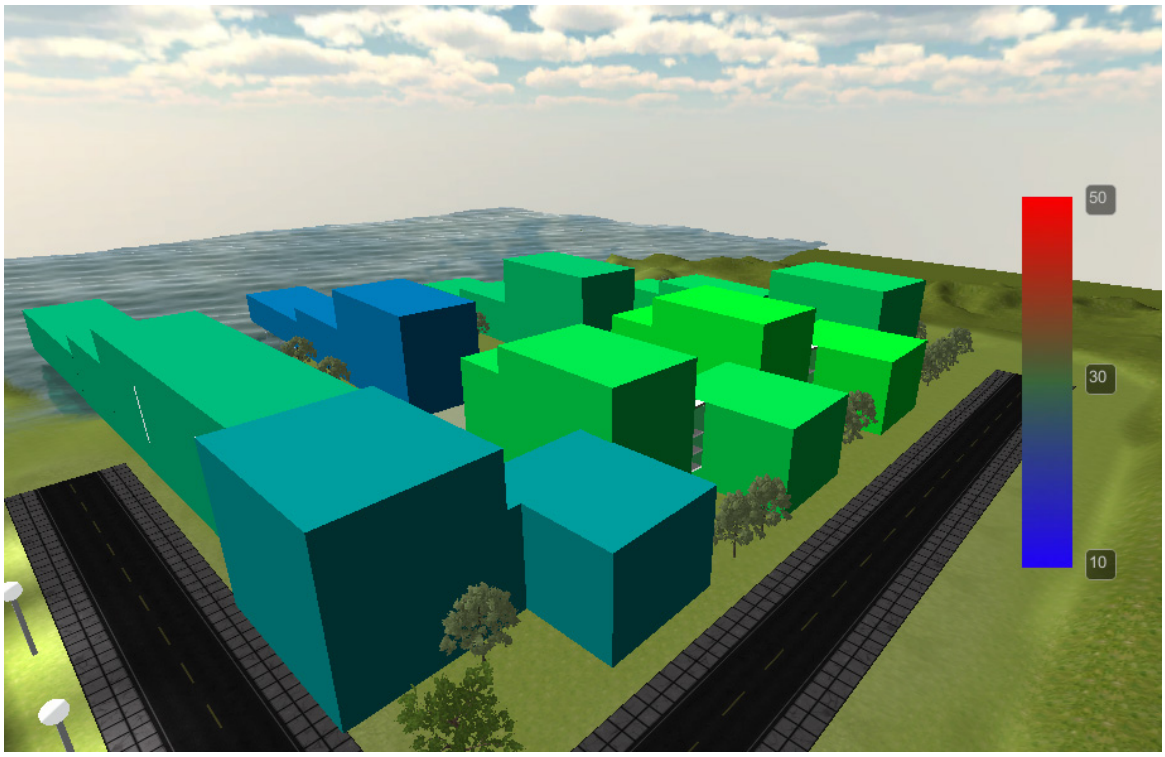


Figure 14. Energy consumption visualized. High values are shown in red colour, medium values in green and small values in blue.

Figure 15. Visualisation of alarms and fault detection. One building is blinking in red.

8.2 Methods

8.2.1 User tests

Because the UnityMerenkulkijanranta tool is planned to be used not only by experts but also by occupants living in the apartments, additional tests were performed with non-experts as the test users. User tests were performed with five participants who were asked to attempt to navigate to the inner court and try the applications. None of the participants works in facility management or a related field. Most of the test users have an average or below average experience as a computer user and none of the test users had used similar kind of game environments before.

The tests were performed using a PC. The characteristics of the test users are presented in Table 15.

Table 16. Characteristics of the test users

- **User group**

Facility management	0
Other expert user	0
Occupants	5
Total	**5**

- **Computer use experience**

Experienced user	1
Other	4
-	0
Total	**5**

- **Age**

18-25	1
26-39	0
40-59	3
60-74	1
Total	**5**

- **Gender**

Female	3
Male	2
Total	**5**

8.3 Findings in user tests

The following findings related to navigation were made in the tests:

- All the five test users tried to navigate by clicking and double-clicking mouse buttons.
- Three of them had to be advised to use the arrows as they did not realize that by themselves in several minutes.
- All the test users noted that the mouse works very sensitively, i.e. a small movement of the mouse has a large effect on the view seen. This was found to be a problem in navigation.
- All the test users were finally able to navigate, more or less fluently.
- The results from these five tests were very similar, i.e. the most significant problems are clear and no more tests are needed (well saturated).

The test users were also asked to try some of the applications. The menu for the applications can be opened by pressing button "u". That information was not available and could not be known by the test users, so they were asked to press that button. The test users were able to choose the applications and to realize the effect of the applications as the colour coding makes it highly visible. In discussions they did not show large interest in the energy behaviour of the neighbourhood area but gave comments that they are mostly interested in information dealing with their own apartment.

8.4 Conclusion: major findings and recommendations

Table 17. Recommendations based on usability study

Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Give guidance for navigation and the shortcuts	Not all were able to navigate in the area before they were given verbal advice for that. The shortcuts of the gaming environment were not known by any of the test users.	high
Make the mouse less sensitive to the movement	All the test users considered the mouse to be too sensitive	high

9. Usability study of Energy Performance Monitoring Tool (UnityMerenkulkijanranta) (third stage)

9.1 Description of the tool

A new version of UnityMerenkulkijanranta was studied by usability tests. This version is, for example, able visualize energy consumption histories (Figures 16-18) in addition to the characteristics in the earlier versions.

Figure 16. Energy consumption visualized over a period of time. High values are shown in red colour, medium values in green and small values in blue.

Figure 17. The options to choose which energy consumption index to visualize

Figure 18. Navigating inside an apartment

9.2 Methods

9.2.1 Expert reviews

An expert of usability evaluated the tool using the methodology described in 3.2.

9.2.2 User tests

User tests were performed with eight participants. The participants attempted completion of the following tasks:

- Find out how large has been the cooling consumption in the area (press ”o” – they were advised to do that since they cannot know the shortcut that opens the options from which “Total cooling energy” needs to be chosen, Figure 17)
- When has the cooling energy consumption been its highest? / Describe with your words the contents you see.
- Exit the section.
- Try navigating in the area

All the participants work in facility management as serviceman or service manager. All the test users were first time users, i.e. none of the test users has earlier used this software. The characteristics of the test users are presented in Table 17. The tests were performed using a PC.

Table 18. Characteristics of the test users

- **User group**

Serviceman (title in Finnish: “huoltomies/-asentaja”)	6
Service manager (title in Finnish: “huoltopäällkkö”)	2
-	o
Total	**8**

- **Education level / Computer use experience**

Education background in technology or a related field	8
-	0
-	0
Total	**8**

- **Age**

18-25	3
26-39	2
40-59	3
60-74	0
Total	**8**

- **Gender**

Female	0
Male	8
Total	**8**

9.3 Findings in expert reviews

The following findings were made in the expert review:

- The size of the window is fixed (manually chosen when the tool is opened) and do not adapt other sizes and do not support changing from the horizontal view to vertical one
- Not all the operations are supported by a touch screen, walking in the area seems not to be possible
- Performance indexes (behind character key “o”) can be visualized over a period of time which is good and could be useful in certain situations. However, this type of presentation does not make it easy to capture information out of it, i.e. a simple chart can carry a lot of information in a format that is easier and faster to interpret. The dates are not easy to follow simultaneously with the visualizations since they are shown in the upper left corner (could be located closer to the visualization).
- Graphical images (behind character key “p”) are of low technical quality (a problem with scaling or too low resolution) in the tested version and are not useful in the present format.
- Make it always easy to return to the previous view (sometimes it is easy, sometimes not). “Close”-button and “Return original colors” could be shown with a different background than the other options, so that it is easy to locate.
- Exiting from the performance indexes should be as easy as possible without remembering any specific shortcut key. A separate button is needed for exiting or ESC button should return to the main view.
- Rotation of the view should be possible during the time when the historical data of performance indexes are shown. It is frustrating when the visualisation starts without a view to the buildings and the view cannot be rotated (this means that the user sees no data).
- Terminology: avoid abbreviations that are not commonly understood (e.g. KPI)
- Arrange performance index options by using headings: Heating, Cooling etc.
- Make it possible to move between the performance index options by arrow keys.
- Show the metric used (e.g. MWh) together with the scale. The users do not remember it from the previous screen.
- More help for using character keys is needed since the users cannot use the system without knowing the correct characters. Why is “o” used for graphical KPIs and “p” for still images? These decisions seem not be “natural” and easy to learn by the users.
- The texts should be generally chosen more carefully to be as understandable as possible.
- Short-cuts are needed for at least for the most important performance indexes (as little steps as possible should be needed for performing the most commonly needed tasks).
- Graphical presentations of data on the walls inside the apartments are not finalized in this version (do not provide understandable information in the current version).
- Separate labels (information only) clearly from the input elements, so that users know which they can edit and which not.

9.4 Findings in user tests

The following findings were made in the tests:

- Those who are familiar similar computer gaming environments (two out of eight in these tests) were able to navigate fluently outside and inside the buildings. They did not need any advice for that but knew the shortcut keys beforehand.
- The other test users tried to navigate by clicking mouse buttons or scrolling with the mouse which did not work in this system. One of them noted that this does not work similarly to Google Maps Street View. Most of them had to be advised to use arrow keys for navigation in addition to the mouse. After giving this advice all the test users could navigate in the area more or less fluently.
- Most of the test users were able to choose correct option (Total cooling energy, see Figure 17). The delay after pressing this option is quite long (seconds), during this time they all pressed it twice or three times. This caused no serious problem but showing a symbol (e.g. sandglass) would help users to understand that the system is already working to fulfil the request given by the users.
- The colour codes and time scale (Figure 16) were generally understood but some misunderstandings occurred. Red colour was understood by one of the test users to refer heating (although it shows in the present figure when the cooling consumption has been its highest).
- One of the test users noted that the consumption data could be presented in a line chart from which the information could be gathered easily.
- It was not clear how to exit from the view since ESC do not work for that (some tried this button). Many of the test users, however, remembered they key “o” and were able to return to the options view. ”Return to original colors” were typically found easily from the options view.

9.5 Conclusion: major findings and recommendations

Table 19. Recommendations based on usability study

Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Give guidance for navigation.	Not all were able to navigate in the area before they were given verbal advice for that. The shortcuts of the gaming environment are not known by everyone.	high
Give guidance for the shortcuts and choose them carefully to be as intuitive as possible	More help for using character keys is needed since the users cannot use the system without knowing the correct characters. Why is “o” used for graphical KPIs and “p" for still images? These decisions seem not be “natural” and easy to learn by the users.	high

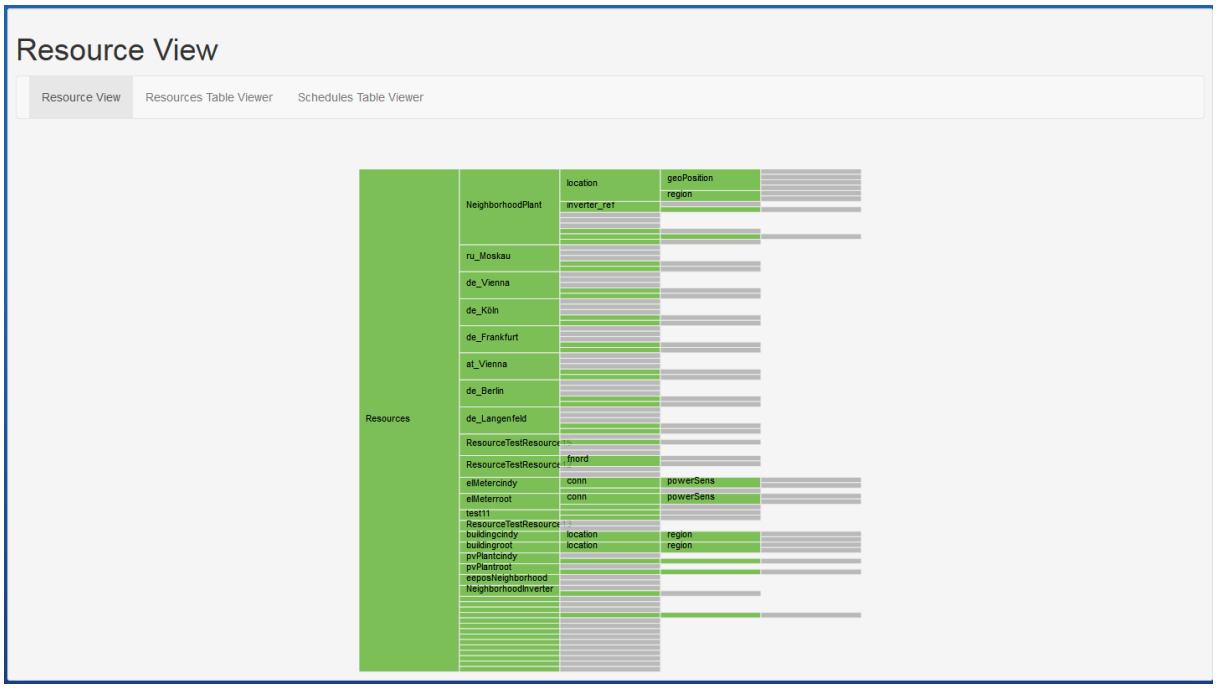
Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Make it possible to use the tool with a touchscreen	Not all the operations are supported by a touch screen, walking in the area seems not to be possible	moderate
Performance index visualizations over a period of time do not make it easy to capture information out of it. Include other kinds of presentations also (some are already included in a separate view).	For example, a simple line chart can carry a lot of information in a format that is easier and faster to interpret	high
Improve technical quality of graphical images	Graphical images (behind character key "p") are of low technical quality (because of scaling or too low resolution) in the tested version and not useful in the present format.	high
Arrange performance index options by using headings: Heating, Cooling etc.	Makes it easier to go through all the options	low
Make it possible to move between the performance index options by arrow keys.	Different kind of input devices should be supported	low
Terminology: avoid abbreviations that are not commonly understood (e.g. KPI)	Not all users understand these	moderate
Add a symbol (e.g. sandglass) if there is an unavoidable delays so that the user knows that the system is already working to fulfil the request given by the user.	The delay after choosing an option (e.g. Total cooling consumption) is long and the test users pressed the option twice or three times before visible action was seen,	low
It should be carefully considered which colours are used in visualizations. Instead of scale consisting of Red, Green and Blue, a single coloured scale could be more appropriate at least in some cases.	Simple colour scales are easier to understand. Red colour may be understood to refer heating.	moderate
Show the metric used (e.g. MWh) together with the scale.	The users do not remember the metric used from the previous screen.	moderate
Separate labels (information only) clearly from the input elements	The users need to know which are input elements and which are not (even though it seems to be clear)	moderate

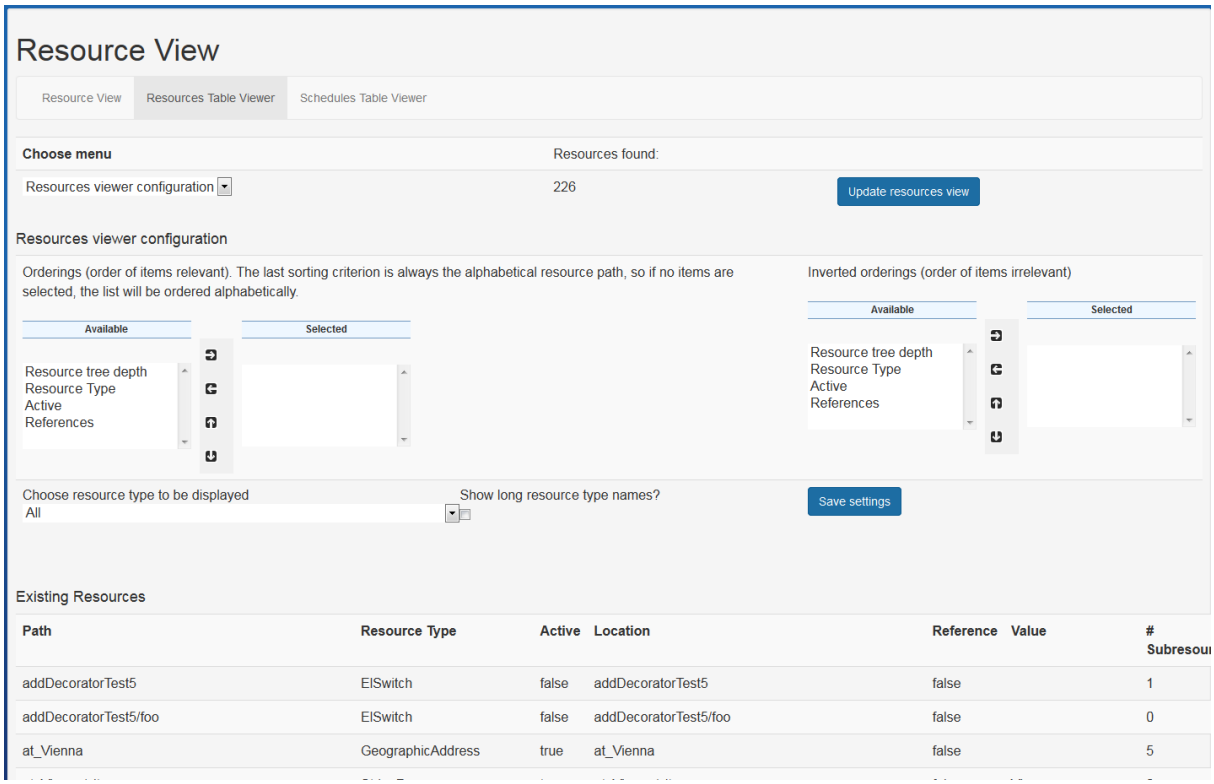
Recommendation (what to change)	Justification (why)	Severity (high/moderate/low)
Rotation of the view should be possible during the time when the historical data of performance indexes are shown.	It is frustrating when the visualisation starts without a view to the buildings and the view cannot be rotated (this means that the user sees no data).	high
Make it always easy to return to the previous view (sometimes it is easy, sometimes not).	The users should have it easy to always return back if needed	moderate
Exiting from the performance indexes should be as easy as possible without remembering any specific shortcut key.	A separate button is needed for exiting or ESC button should return to the main view.	moderate
Improve graphical presentations of data shown on the walls inside the apartments	These are not finalized in this version (do not provide understandable information in the current version).	moderate

10. Usability study of Neighborhood Automation System (first stage)

10.1 Description of the tool

The Neighborhood Automation System (NAS) is intended for supervisory and predictive control of neighbourhood-level energy management. Its primary user group are administrators who set the neighbourhood-level energy management system up and then let it operate autonomously. While it does have functions for supervising system data derived from the OGEMA Framework, the NAS installation is not intended for casual end users – in fact, end users could cause problems for the system by changing its overall settings. Nevertheless, for the purposes of testing the administrative user interface, three applications running on a test server were selected and instructions provided to outside reviewers for how to access the system. These applications were:





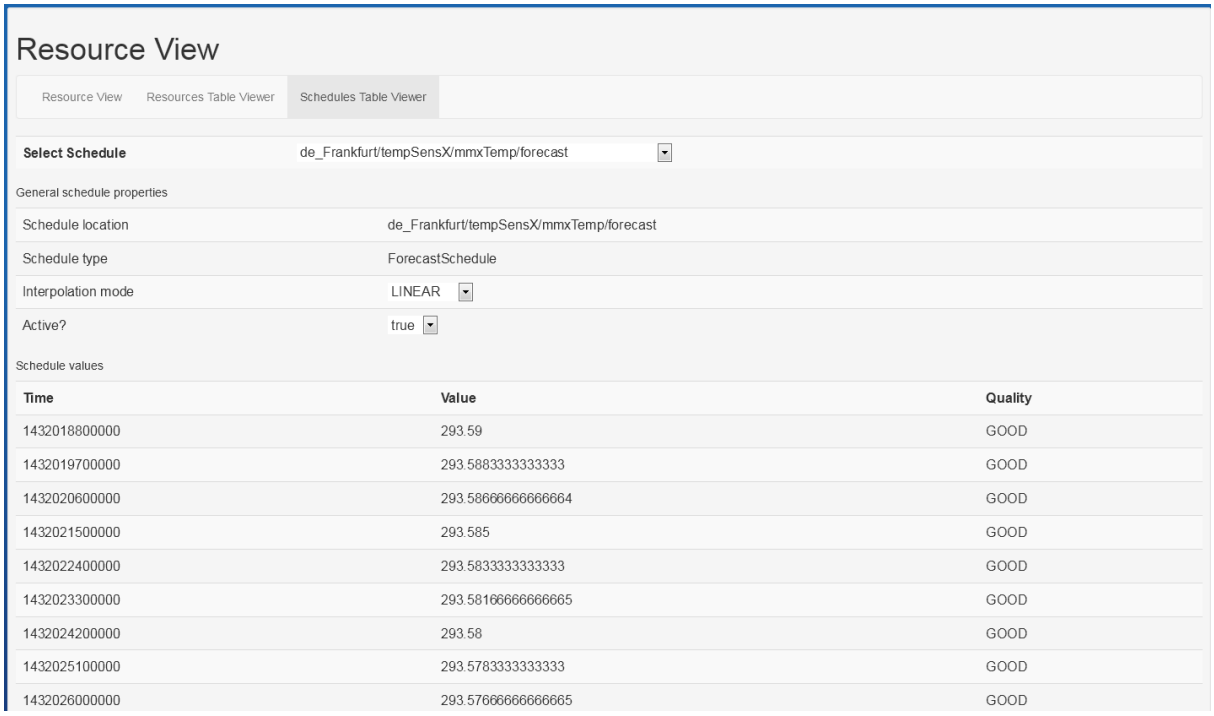


Figure 19. Resource View: A core OGEMA application providing an overview of all registered OGEMA Resources (system data) and their current values.

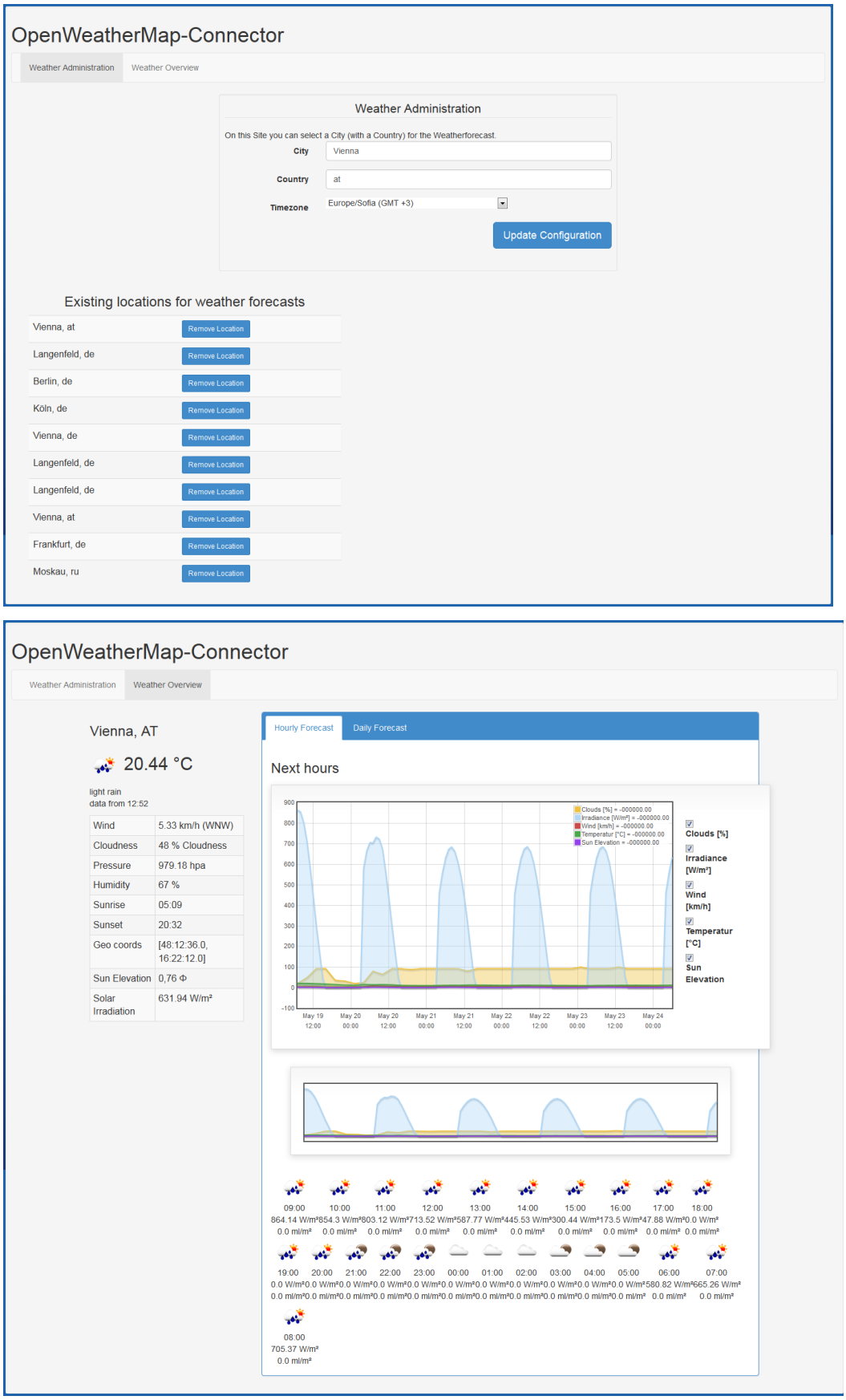


Figure 20. OpenWeatherMap Connector: An application retrieving, storing and displaying weather data from the website OpenWeatherMap.

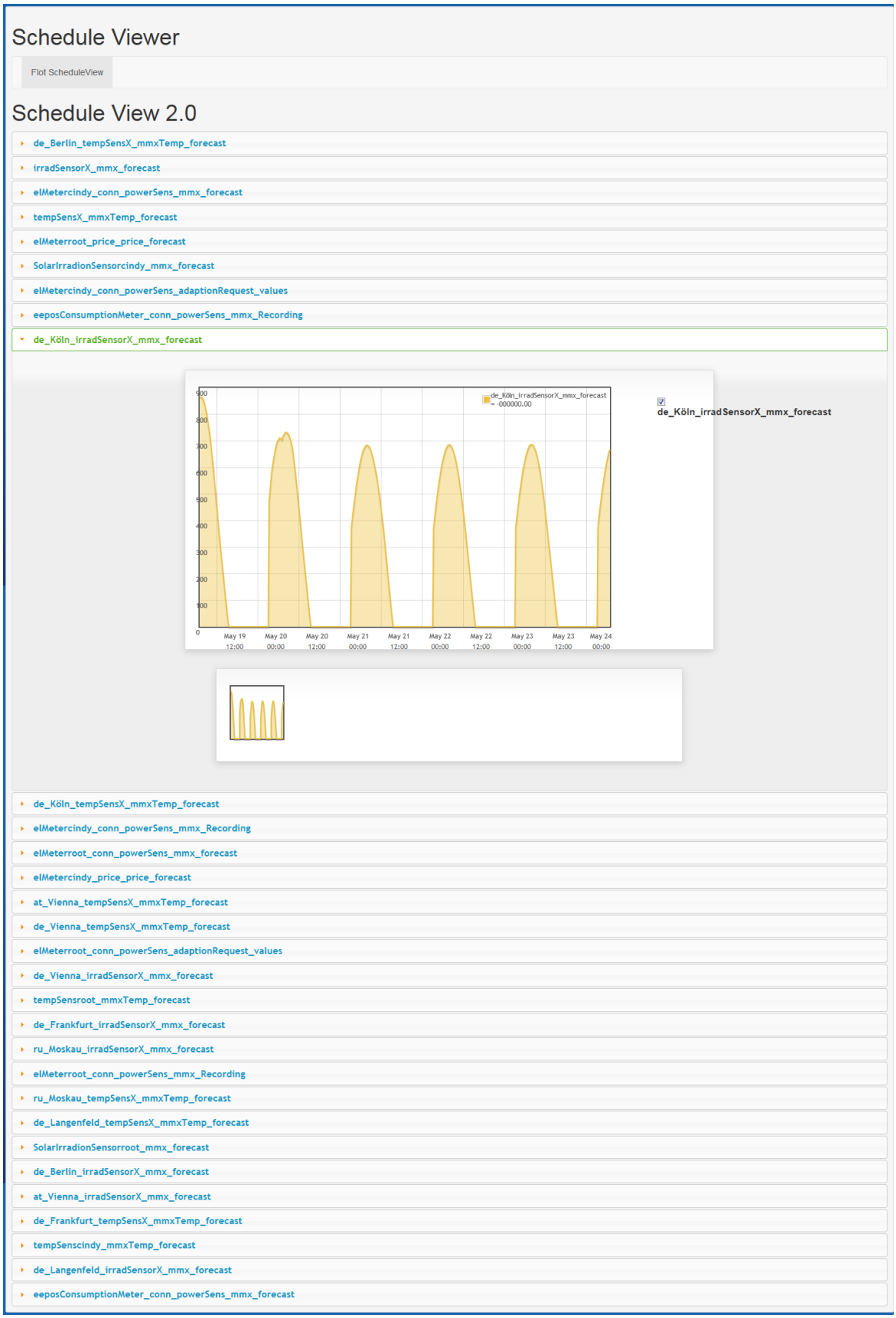


Figure 21. Schedule Viewer: A core OGEMA application for displaying schedules (such as load or electricity production forecasts).

10.2 Methods

Surveys in PDF form were sent to volunteers. The instructions were intentionally kept short so that the participants could complete the survey in less than 30 minutes. Seven participants provided feedback. Some of the questions in the surveys were multiple choice, with ratings from "1" ("Strongly Disagree") to 5 ("Strongly Agree"). Mean values for the answers are listed below. Other questions required text answers, which are summarized below.

10.2.1 Resource View Application

1. This application helps me find current system resources quickly: 2.9

2. This application helps me easily double-check the status of current system resources: 2.7

Two participants reported errors while displaying pages. Other comments focused on the lack of clarity of the display labels or made suggestions for improving the format.

10.2.2 Open WeatherMap-Connector Application

1. The weather forecast information displayed is useful: 3.1

While the display itself was appreciated, comments focused on the slow load speed and made suggestions for improving particular aspects of the display.

10.2.3 Schedule Viewer Application

1. The format in which the schedules are displayed is useful: 2.3

Again, several suggestions on improving labels were made.

10.2.4 General Questions

1. I think that I would like to use this system frequently: 2.3

2. I found the system unnecessarily complex: 3

3. I thought the system was easy to use: 2.9

4. I think that I would need the support of a technical person to be able to use this system: 2.1

5. I found the various functions in this system were well integrated: 2.3

6. I thought there was too much inconsistency in this system: 3.3

7. I would imagine that most people would learn to use this system very quickly: 3.6

8. I found the system very cumbersome to use: 3

9. I felt very confident using the system: 3.1

10. I needed to learn a lot of things before I could get going with this system: 3

While some of these answers were due to the fairly short explanations they were required to read – a necessity due to the nature of the survey - as well as some lack of clear labels, it is encouraging that most users thought that the system would be easy to learn even for nontechnical people. As the NAS is intended primarily for administrative instead of casual users, they would presumably commit sufficient time to familiarizing themselves with the system.

10.2.5 About the Reviewers

Five of the reviewers were in the age category “30-39”, while two were in the age category “40-49”. Only one participant had any experience in the energy sector (5-8 years), while two persons had 9-12 years of experience and two persons had 13+ years of experience in the IT/ICT sectors – all of whom were working in the Education sector.

10.3 Conclusion: major findings and recommendations

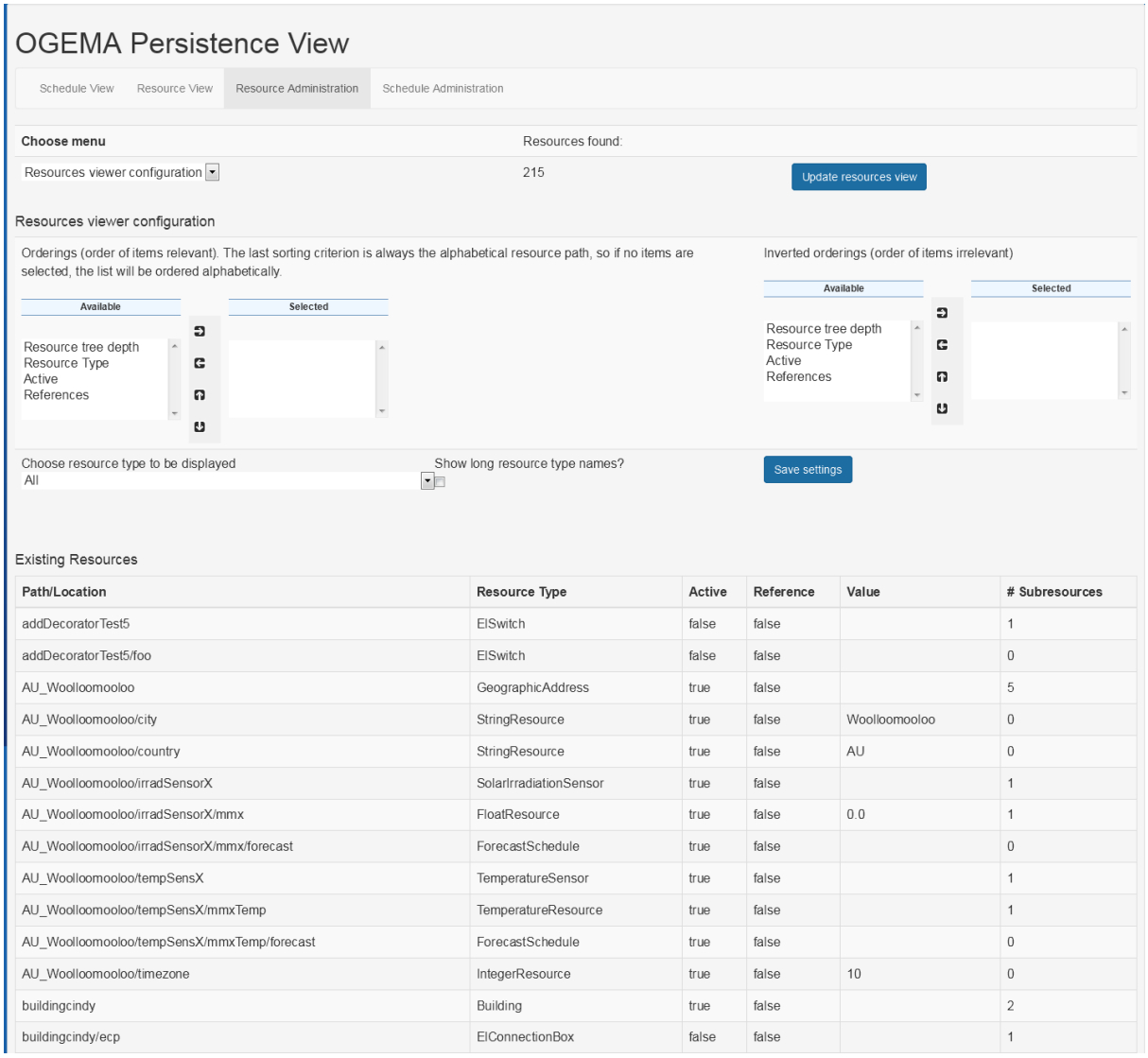
The main priority on improving the User Interface of the NAS should be on fixing the reported display errors and the occasional slowness of the display (if that can be fixed instead of being a function of the test server). After that, the labels of the various displays should be improved and “hover texts” added to various elements so that users can understand them without having to read lengthy documentation.

Some users also expressed a wish for a greater integration of the various applications – that is, the ability to jump between applications by clicking on texts and labels for particular resources instead of using the sidebar. However, this may require changes in the core applications of the OGEMA Framework instead of the component applications of the NAS, and thus must take a lower priority for the purposes of this project.

11. Usability study of Neighborhood Automation System (second stage)

11.1 Description of the tool

Due to complaints about interconnectability and clarity raised during the first survey round, the Resource Viewer and the Schedule Viewer were combined into a new app, the **OGEMA Persistence View**, which combines both of their function while making several improvements to the user interface.



Path/Location	Resource Type	Active	Reference	Value	# Subresources
addDecoratorTest5	ElSwitch	false	false		1
addDecoratorTest5/foo	ElSwitch	false	false		0
AU_Woolloomooloo	GeographicAddress	true	false		5
AU_Woolloomooloo/city	StringResource	true	false	Woolloomooloo	0
AU_Woolloomooloo/country	StringResource	true	false	AU	0
AU_Woolloomooloo/irradSensorX	SolarIrradiationSensor	true	false		1
AU_Woolloomooloo/irradSensorX/mmx	FloatResource	true	false	0.0	1
AU_Woolloomooloo/irradSensorX/mmx/forecast	ForecastSchedule	true	false		0
AU_Woolloomooloo/tempSensX	TemperatureSensor	true	false		1
AU_Woolloomooloo/tempSensX/mmxTemp	TemperatureResource	true	false		1
AU_Woolloomooloo/tempSensX/mmxTemp/forecast	ForecastSchedule	true	false		0
AU_Woolloomooloo/timezone	IntegerResource	true	false	10	0
buildingcindy	Building	true	false		2
buildingcindy/ecp	ElConnectionBox	false	false		1

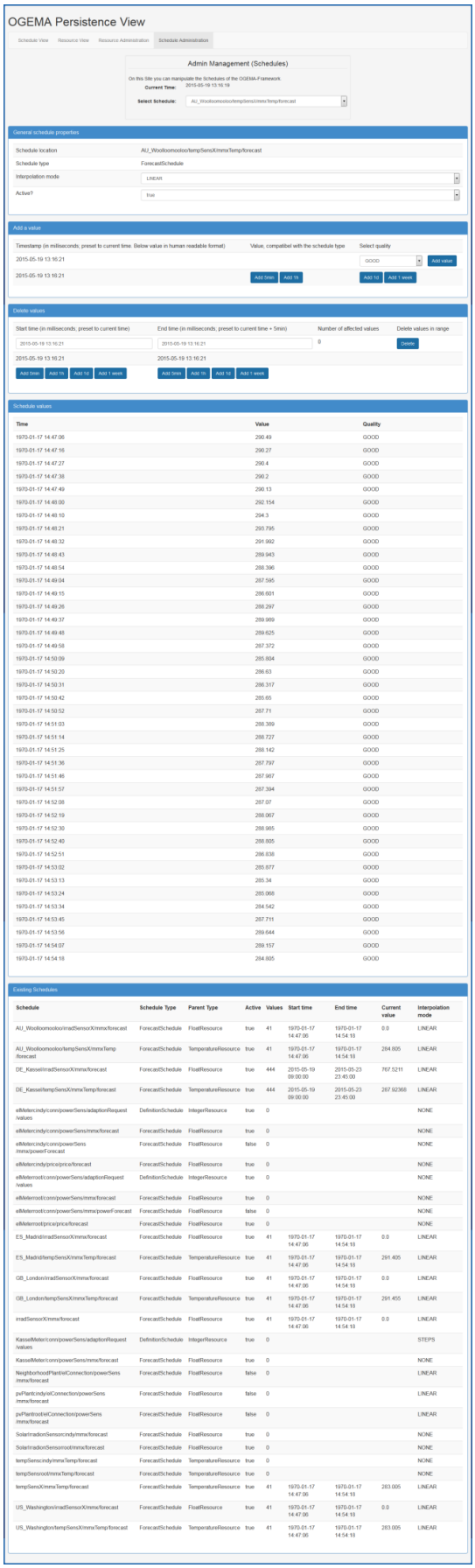
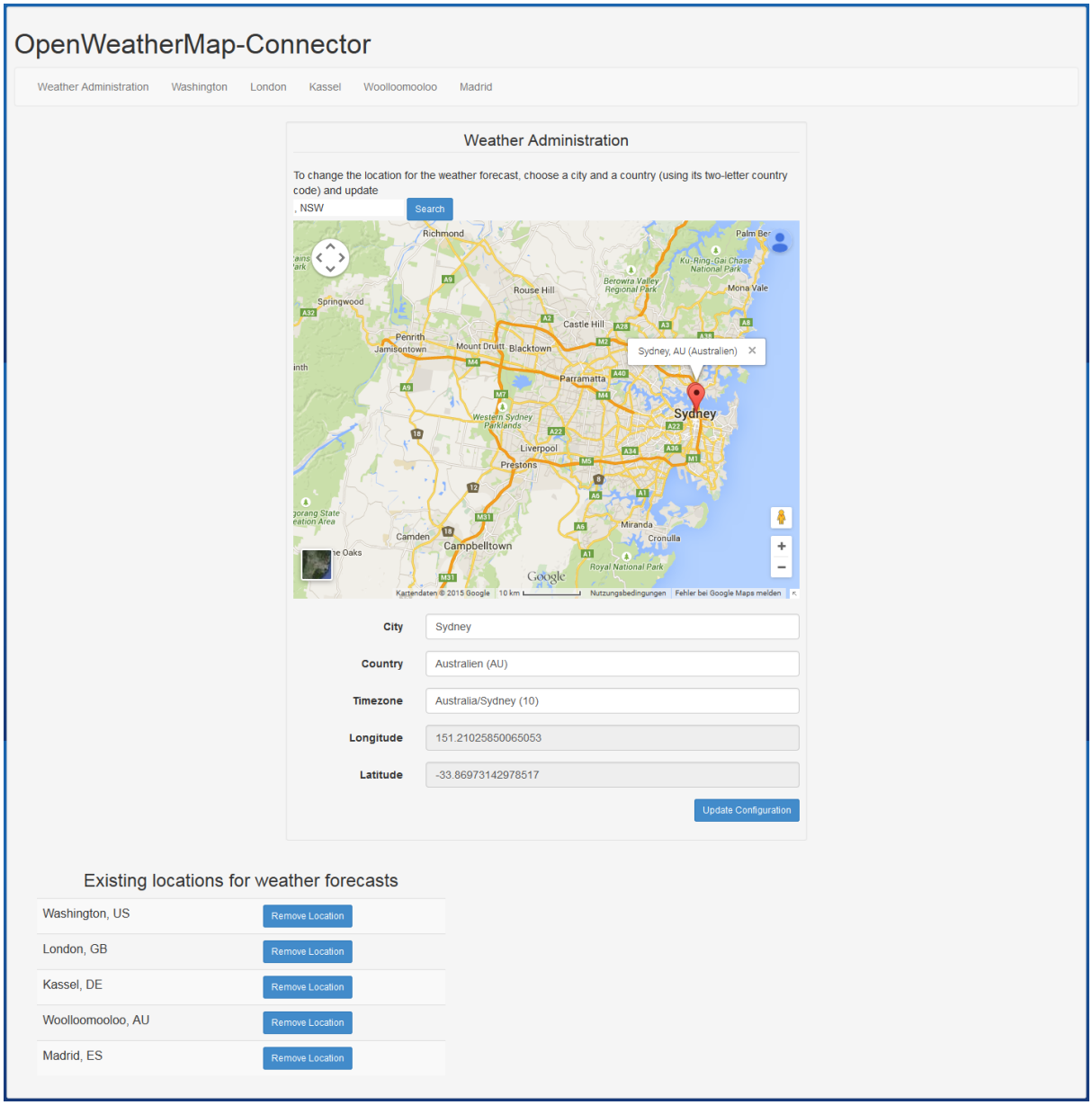


Figure 22. OGEMA Persistence View

The basic functionality of the **OpenWeatherMap Connector** application was not changed, but in addition to small tweaks to its display, its administrative interface was overhauled by allowing administrators to pick a location based on the Google Maps interface and API. Furthermore, each new location added is now represented by its own tab.



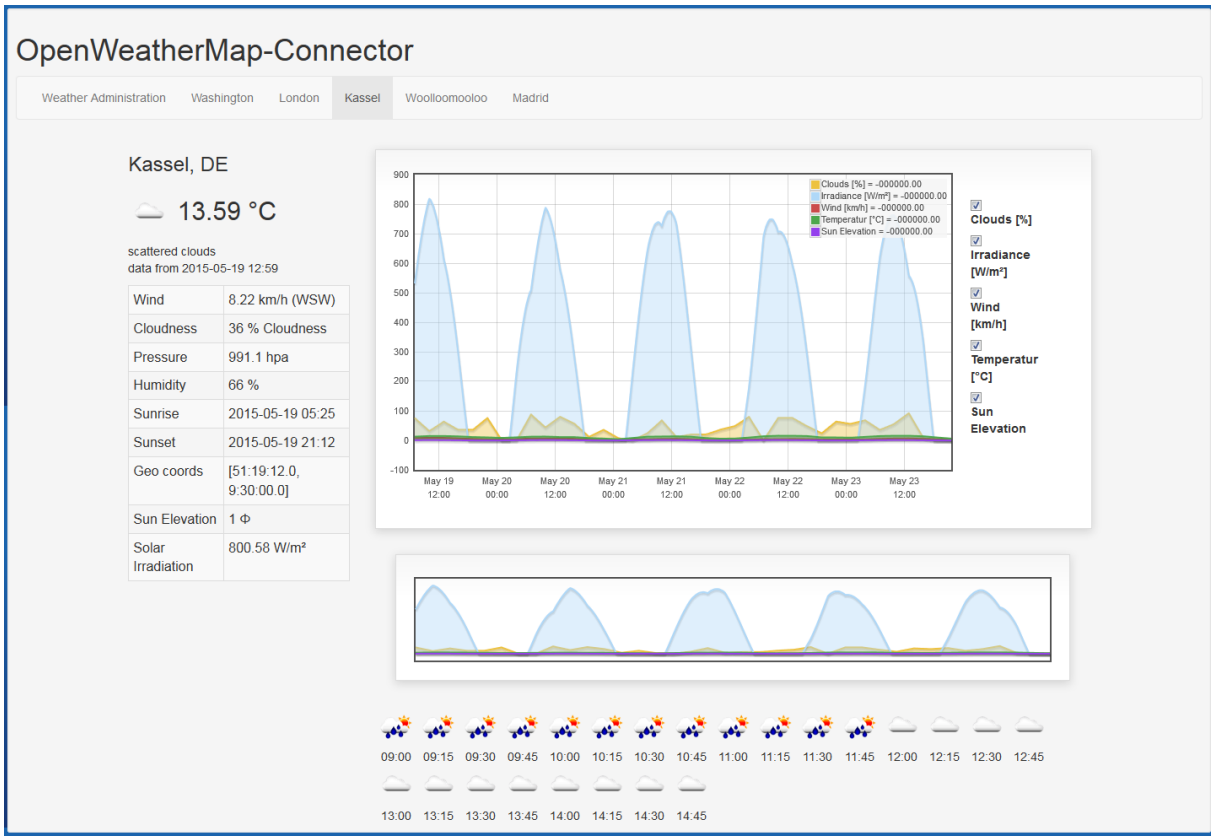


Figure 23. OpenWeatherMap Connector

11.2 Methods

Again, surveys in PDF form were sent to volunteers. The instructions were intentionally kept short so that the participants could complete the survey in less than 30 minutes. Four participants provided feedback. Some of the questions in the surveys were multiple choice, with ratings from "1" ("Strongly Disagree") to 5 ("Strongly Agree"). Mean values for the answers are listed below, as well as the change from the previous survey. Other questions required text answers, which are summarized below.

Note that the questions for the Resource Viewer and the Schedule Viewer were combined for the OGEMA Persistence View.

11.2.1 OGEMA Persistence View Application

1. This application helps me find current system resources quickly: 3.3 (+0.4)

2. This application helps me easily double-check the status of current system resources: 2.8 (+0.1)

3. The format in which the schedules are displayed is useful: 2.5 (+0.2)

Several comments focused on how they felt that in-depth instruction was needed for this application.

11.2.2 Open WeatherMap-Connector Application

1. The weather forecast information displayed is useful: 3.3 (+0.2)

Most users reported the slow speed of this application – elements did not load or did not react.

11.2.3 General Questions

1. I think that I would like to use this system frequently: 3 (+0.7)

2. I found the system unnecessarily complex: 4 (+1)

3. I thought the system was easy to use: 2.5 (-0.4)

4. I think that I would need the support of a technical person to be able to use this system: 3.3 (+1.2)

5. I found the various functions in this system were well integrated: 2.7 (+0.3)

6. I thought there was too much inconsistency in this system: 4.3 (+1)

7. I would imagine that most people would learn to use this system very quickly: 2.8 (-0.6)

8. I found the system very cumbersome to use: 3.3 (+0.3)

9. I felt very confident using the system: 32.3 (-0.8)

10. I needed to learn a lot of things before I could get going with this system: 4 (+1)

11.2.4 About the Reviewers

One of the reviewers was in the age category "30-39", another reviewer was in the age category "40-49", while two more reviewers were in the age category "50-59". Only one participant had any experience in the energy sector (13 years), while one person had 9-12 years of experience and three persons had 13+ years of experience in the IT/ICT sectors – all of whom were working in the Education sector. Professions included "Financial/Business Analyst", "Front-End Web Developer", "Software Engineer", and "IT/Security Management". Business sectors included "Finance/Insurance", "Web Developer", "Telecom/E-Commerce", and "Research".

11.3 Conclusion: major findings and recommendations

While the individual applications were rated better than their previous versions, this came at a cost to the overall system. The initial system was intended to be set up once by an experienced administrator which would then accumulate data and send information via the OGEMA REST interface to the other systems (the ICT platform and the Building Automation System), and was never intended to be used by untrained users. The server used for testing purposes was thus very low-powered, yet was still sufficient for those needs.

However, after the first round of the Usability Study, greater focus was put on the ease of use of the system. This resulted in a better display of the information, but came at a cost of computational resources. This was especially evident for the OpenWeatherMap Connector app, which not only displays maps but also needs to connect to the Google Maps API in addition to OpenWeatherMap for this information, which apparently proved too much for the test server. Running the NAS on a more powerful server should alleviate this problem, though this runs counter to the initial idea of saving energy.

A further complication is that the NAS only has an administrative interface, as opposed to the user interfaces of the ICT platform and the BAS that are supposed to be used by unskilled end users. As the NAS can affect the energy consumption of an entire neighbourhood, it represents a critical nexus within the EEPOS infrastructure that should only be set up by a skilled person who has received a day or more of training. Yet replicating this was not possible within the confines of the usability study, as requiring the participants to spend several hours reading documentation would have reduced the pool of volunteers even further.

12. CONCLUSIONS

12.1 Summary of achievements

The usability of several energy management tools developed in other WPs and tasks was studied in the present Task 4.5. The study methods involved both expert reviews (heuristic evaluation) and user tests in which test participants tried to accomplish pre-defined tasks. In the user tests the completion rates were recorded and verbal feedback was gathered. In addition, short questionnaires were performed after the tests in certain cases.

The results of the usability studies were delivered to the developers of the tools to be used in improving the usability of the tools. A simple way of presenting the results was applied: the tables show 1) recommendation (what to change), 2) justification (why) and 3) severity rating (high/moderate/low).

This task was planned to be performed during a period of one year. The first usability tests were performed soon after the beginning of the task (spring 2014) for all the tools of which a prototype was available. More usability tests were performed during the autumn of 2014 and the spring of 2015. In all the periods the tests involved those tools of which a new prototype was available for testing.

The usability tests revealed a large number of usability problems, some of them have a high severity rating. Fixing the problems with a high severity rating is essential for improving the usability of the tools but it is recommended to fix all the problems found. A part of the usability problems have already been fixed during the running time of this task.

A manuscript for a scientific article entitled “New tools for visualising building performance in the building and neighbourhood level” has been written. A central part of the contents are the results from the usability study performed in this task.

12.2 Relation to continued developments

The tools under the usability studies are to be demonstrated in WP5. The results of this task give feedback on how to improve the usability of tools, i.e. the target is to make the tools easier to understand and use, to improve user satisfaction, to improve the productivity of users – and generally – to improve the product quality.

12.3 Other conclusions and lessons learned

The test users generally encountered similar usability problems with each other. This gave clear ideas on how to improve the usability of the tools. The expert reviews were useful as a complementary method but not suitable to be the main method if the purpose is to find out the real life usability problems.

13. ACRONYMS AND TERMS

Expert review ..... Evaluation of the usability of a product by experts

KPI ..... Key Performance Indicator

Usability ..... The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO 9241-11)

Usability test ..... Evaluation of the usability of a product. General term that includes both expert reviews and user tests. Sometimes used as a synonym to user test.

User test..... Evaluation of the usability of a product by tests that involve potential users as test participants.

14. REFERENCES

[1] Nielsen, J. 1995. Ten usability heuristics. Available: http://www.useit.com/papers/heuristic/heuristic_list.html
[2] Nielsen, J. 2000. Why You Only Need to Test with 5 Users. Available: http://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/
[3] Anon 2011. A guide to carrying out usability reviews. UX for the masses. Available: http://www.uxforthemasses.com/usability-reviews/