ICT-tools in Energy Planning

Good Practices Report

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By

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1. Introduction

One of the objectives of the AREA 21 project is to develop three different ICT-tools, which could be used in energy planning, energy management and to engage users to raise their awareness of energy usage. The three tools are being developed by separate project partners and are characterized as:

- Holistic system tool, developed in Tampere by Tampere University of Applied Sciences (TAMK);
- Innovative online tool, developed in Tartu by Tartu Regional Energy Agency (TREA);
- Energy improvement circle tool, developed in Helsingborg by Öresundskraft AB.

Research of current good practices for ICT-based energy planning tools informed the approach of the AREA 21 project in its own tool development. This Report provides an overview on the research findings of ICT-tools from partner regions which preferably have been in use for some time and have a solid share on the market.

The three new tools are developed in the framework of the fourth Work Package (WP4) in the AREA 21 project framework; dedicated to the topic of citizen involvement in energy planning and implementation. The intent of this activity is to understand the potential of ICT-based tools to involve citizens as property users and owners in the planning and implementation of energy efficiency measures. Also, to understand what possibilities ICT-tools offer citizens to enable them to actively participate in the energy planning of their apartment, building and the district where they live. Further, how can ICT-tools raise awareness about energy use at an individual level?

This work was assigned as Group of Activities 4.1 (GoA 4.1). The first activity involved a review of previous research conducted on energy feedback devices and energy planning participation tools. This Report presents the methodology that was used in the identification process and the reasoning behind the selected method. The method formed a guideline for Project Partners towards identifying relevant and useful ICT-tool examples to support the development of AREA 21 ICT-tools.

The results section of this Report provides an overview of the ICT-tool good practices discovered including key features and their relevance to the selection criteria. The Report concludes by identifying the tools most relevant for the purposes of the AREA 21 project, with some overall concluding comments from the identification process.

2. Background research on citizen participation in energy planning and usage

2.1. General energy reduction potential of energy monitoring

In recent years the concepts of energy monitoring, ICT supported energy efficiency in buildings and citizen involvement have been a topic of several studies. Many studies have concluded that energy consumption displays at home can contribute to reducing energy consumption. La Marche et.al. (2014) assessed that this

reduction could be between 4-13 %. Referring to several sources Burchell et.al. offers a range between 3-19 %. The savings are depending largely on the feedback formats, programme designs and cultural, market and infrastructural contexts. (Burchell et.al. 2016)

It may also be worth noting the obvious: The mere monitoring itself does not save energy but rather any savings that may occur are heavily reliant on the human factor. Interaction between energy monitor and the user is needed and the eventual savings are a result of actions taken by the user. (Buchanan et.al. 2015)

The full potential of automated energy optimisation and control is outside of the scope of this ICT-tool identification process, as these kinds of systems are still yet to find themselves in a larger scale in the homes of ordinary citizens.

2.2. General interest in energy monitoring

Although several studies have shown that energy monitoring can save energy, a key finding indicates that this reduction is unlikely to persist over a longer period of time, as the user's attention is not sustained by new information. (LaMarche et.al. 2014)

According to Buchanan et.al. (2015) the waning interest after the initial novelty of energy monitoring may be one of the largest obstacles to the success of feedback based devices. A quote from a monitoring study summarises the issue succinctly: "My apartment was really small, so I learned the energy use combinations very quickly. Once I figured that out over the first week, not much new info since" (LaMarche et.al. 2014, P26).

Studies have shown that energy consumers have limited interest in energy monitoring devices, for example a survey conducted in the United Kingdom revealed that 59 % of bill-payers expressed no interest in having an In-House Display installed in their homes (Buchanan et.al. 2015). Another example can be found in the United States of America where a free Home Energy Display was offered as part of a research project. Only 8 % of the building tenant population opted to receive this free display (LaMarche et.al. 2014).

2.3. Barriers of adopting energy monitoring

As there is a low interest in energy monitoring devices, there is a clear need to identify what kind of barriers may be expected when trying to adopt new energy monitoring ICT-tools. In particular, it is important to find out how to sustain the energy consumers' interest in their monitoring devices.

One study conducted in the United Kingdom examined the possibilities of integrating social media into energy saving behaviour. This study assigned a group to use social media and give feedback on energy related issues in their workplace. The study identified that participants had limited interest to adopt the technologies, expressing concerns about social media privacy, being unhappy with "oversharing" their personal details online preferring instead to follow newsfeeds rather than post information themselves. The project concluded that two significant changes were trying to be realised: fostering greater collaboration and smartphone/social media applications. (Bull et.al. 2015)

Information that is delivered to a user needs to be understandable and reliable to sustain engagement. This is highlighted by research undertaken by Buchanan et.al.: "[...] given that the consumers understanding of their energy bill is already low, it is possible that presentation of 'meaning-less' live numbers or cumulative information about daily or weekly consumption may only confuse them further" (Buchanan et.al. 2015). A poorly working energy monitoring will also discourage interest as stated by an energy monitor user in the study of LaMarche et.al (2014, P26): "I still think the device would be useful if I felt the information displayed was accurate in any way".

2.4. Preferred and engaging features

Usability and understandability seem to be the most highly appreciated features for an energy monitoring tool: "Users are more willing to spend time with an energy feedback device if it rates highly on usability (i.e. presents information that is well designed, simple and attention grabbing)". (LaMarche et.al. 2014, P11)

One of the sought-after features of energy monitoring are alerts. By definition they alert the user and therefore engage them into either awareness or action. This is stated by LaMarche et.al. (2014, P14): "Because alerts can often be part of display settings, they might not be well visualized, but they are highly regarded for their value".

Simple energy consumption indicators were also appreciated by a study group described by LaMarche et.al.: "It is possible that basic Home Energy Displays alone will not maintain consumer interest. Other options transform raw data into more relevant consumer-oriented information". For example, a "traffic light" representation on current energy consumption was regarded as an understandable way of presenting energy consumption levels. (LaMarche et.al. 2014, P5)

However, it should be noted that certain types of feedback may even increase energy consumption if they lead the consumer to believe they are low energy users compared to others. For example, some study participants sometimes interpreted green or orange lights as approval for existing levels of consumption. (Buchanan K., et.al. 2015)

Another example of understandable information is offered by Buchanan et.al.: "Householders have to deduce which changeable aspects of their lifestyle contribute significantly to their consumption … confusion may be exacerbated by the fact that there is no information in a disaggregated form (e.g. appliance level) to which consumers can relate their energy using practices." (Buchanan et.al. 2015, P92)

2.5. Lessons learnt from background research

The conducted research enables the conclusion that while energy monitoring has the potential to reduce energy consumption the effects may be short lived due to the diminishing interest of the user over the long term. Also, in general there can be limited interest to adopt monitoring devices, and users who adopt the device may lose interest to follow energy consumption if it provides limited new information over time.

Energy is an abstract concept and a lack of citizen interest provides a challenging field for any commercial tool with participatory features. Some of the conditions that can be measured, in a dwelling for example, may be

more concrete for citizens though. For example, temperature and humidity are measurables to which any citizen can relate to. CO_2- and lighting levels may be a little bit more unrelatable but not out of reach with little guidance.

Key findings from this background research influenced the selection criteria for the ICT-tool good practice research. The qualifying criteria (as presented in section 3.2) seek to address some of the problems presented above, including the following:

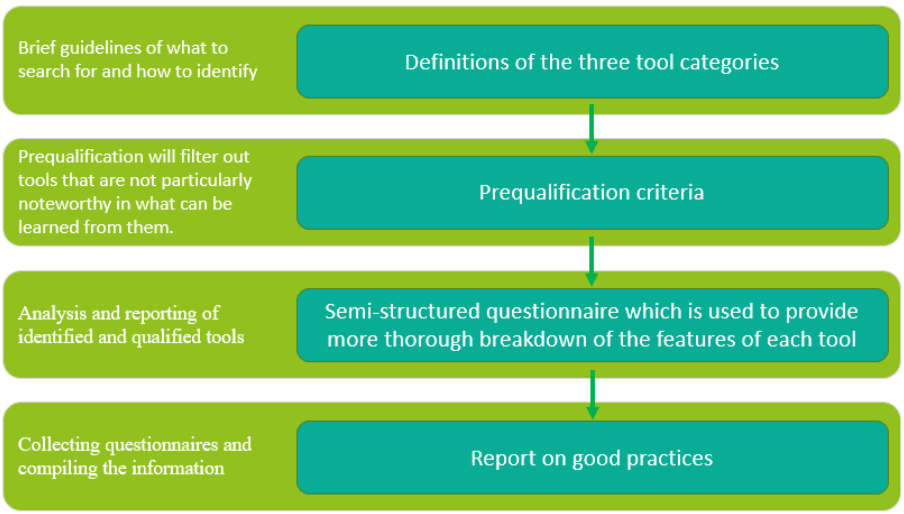
- The tool engages user to a long-term involvement;
- The tool combines data from different sources;
- The tool supports setting goals or achievements and follows the progress;
- The tool provides energy consumption data on an appliance level;
- The tool is particularly informative and easy to use; and
- The tool has some form of social media connection.

3. Good practice identification methodology

In order to support the development of the three new AREA 21 project tools, a methodology was used to find good practice energy planning ICT-tools for guidance. A set of criteria was formulated, informed by the three different tool characteristics and the background research. These criteria were to be used to find types of ICT-tools with certain features.

The method undertaken comprised two phases (see Figure 1). The first phase was identification and prequalification. The second phase involved analysis. The identification phase selected tools in the market that fit criteria characteristic of one or more of the three AREA 21 ICT-tools to be developed. The identified tools were then further filtered by a set of criteria to determine the most promising technologies for further investigation. The filtering was undertaken based on questions described in this section.

Figure 1. Overview of used methodology



Source: Author's own visualisation (2019)

3.1. The three different types of tools

When a search for the good practices was undertaken, consideration was given to how tool features are relevant to at least one of the three types of tools that will be developed in AREA 21. Some identified tools included features which were relevant to more than one type of tool described below. In such cases it was feasible to implement more than one set of criteria and use the methodology more flexibly.

The three AREA 21 ICT-tools that will be developed are described as:

- Holistic system tool (tool number 1);
- Innovative online tool (tool number 2); and
- Energy Improvement Circle tool (tool number 3).

In this Report these tools will also be referred to with their respective numbers. The key characteristics for each of the tools are outlined below.

3.1.1. Holistic system tool

The holistic system tool describes a system that measures building energy and water consumption and the conditions in real time. The tool will provide feedback to the user in the form of raw data, performance indicators or graphs, and can be used at an apartment level and whole building level by tenants. Tampere University of Applied Sciences is developing and testing the tool in a student dormitory in Härmälä, a district in Tampere, Finland.

3.1.2. Innovative online tool

The innovative online tool will guide energy users through the energy auditing procedure. The tool will gather data on energy consumption and produce reports based on the consumption data, in order to suggest potential energy saving changes in the tenant's behaviour. A key feature of this tool is benchmarking and it will be referred to as the benchmarking tool in this Report. Tartu Regional Energy Agency is developing and testing the tool in Annelinn, a district in Tartu, Estonia

3.1.3. Energy improvement circle tool

The energy improvement circle tool will monitor, manage and optimize energy production and consumption of an energy network. The tool will be able to combine the management of local energy production, heat recovery systems and energy consumption into one energy improvement circle. Demand response solutions will provide a platform for promoting reasonable energy consumption and a new culture of energy use. Öresundskraft AB is developing and testing the tool in a hospital in Helsingborg, Sweden.

3.2. Qualifying features

The criteria used to select good practices on ICT-tools for energy planning are listed below. A tool needed to match at least one or more of the criteria.

- The tool engages user to a long-term involvement;
- The tool is used to supplement energy planning;
- The tool combines data from different sources;
- The tool explains how energy is used in the apartment;
- The tool explains how energy is used in the building;
- The tool explains how energy is used in the district;
- The tool supports setting goals or achievements and follows the progress;
- The tool is used for benchmarking and reporting;
- The tool supports energy demand forecast, optimization and controlling;
- The tool formulates tailored tips on how to save energy in apartment, building or district level;
- The tool supports energy auditing;
- The tool provides energy consumption data on an appliance level;
- The tool integrates indoor climate (temperature, ventilation rates, humidity, CO2, etc);
- The tool is particularly informative and easy to use; and
- The tool has some form of social media connection.

3.3. The questionnaire

After an ICT-tool was qualified by the selection criteria explained in section 3.2 a more thorough examination was made to provide more information of the tool for developmental purposes. For this purpose, an Excel based questionnaire was formulated to provide an aggregated breakdown of the ICT-tools' features and background. Each Project Partner was asked to search, find and deliver three example cases of ICT-tools from their respective countries.

The questionnaire was used in two phases. In the first phase the questionnaire was given to Project Partners for testing and feedback on the methodology. In the second phase a revised questionnaire was used for the collection of more good practice ICT-tool examples. Table 1 summarises the main topics of the questionnaire, which is available in full in Annex 1 of this Report.

After the first round of searching for ICT-tools, some additional examples were added into the collection to ensure there was a good representation of different features. The questionnaire was not used when the additional examples were added.

Table 1. Topics and questions used in the questionnaire

0	**Qualification criteria**		
0a	ICT-tool must at least somewhat fit into at least one of the three tool categories		
0b	Further qualification criteria. ICT-tool must meet at least one criterion (elaborated in section 3.2)		
1	**Basic information and qualification**	**2**	**Implementation and data management**
1a	Name of the tool	2a	The purpose of the tool
1b	The origin of the tool	2b	The level of implementation
1c	Financing	2c	The scope and level of measurements or data
1d	Further information	2d	The source of the data
1e	Tool category	2e	Data storage
1f	The good practice features	2f	Data ownership and access
		2g	The equipment overview
		2h	Measurements accuracy
3	**User experience**	**4**	**Sensors and data collection**
3a	User Profile	4a	Data ownership
3b	User interface	4b	Data saving
3c	What user sees	4c	Sensor performance
3d	User engagement	4d	Sensor reliability
3e	Usability		
3f	Tool training and motivation		

Source: Author's own visualisation (2019)

4. Results

4.1. Overview of the collected ICT-tools

The full collection and short descriptions of each tool can be found in table 2. Table 3 presents the location of each tool and the key feature why it was included in this collection and why it was deemed a helpful reference for AREA 21 ICT-tool development. In total 22 tools were collected from 7 countries.

Table 2. Short descriptions of each tool. The tool names include clickable link to external web site with further information.

AMI system	AMI system is a Polish tool that can be used to monitor and control energy consumption and compare it with other consumers of comparable energy usage profiles in similar periods of time. The tool present information about planned works to be carried out on the network and status of removing failures. The tool can also be used to send messages and notifications individually and collectively
DOMATIQ	Domatiq is a building automation system which can be used to control building assets and optimize use based on energy consumption profiles. The tool can also be used to make cost simulations with different energy tariffs. The tools can combine data from different sources of data.
E-elering	In e-Elering every energy consumer can monitor his or her electricity and natural gas consumption and also compare consumption worth other similar customers. The user has the option to share the data with others and see who has used the data.
Eesti Energia app	Eesti Energia's mobile app allows one to keep an eye on electricity consumption with the accuracy of one hour, enabling one to change their consumption behavior based on the consumption and price information provided. The app will also notify if the users electricity consumption differs considerably from ordinary pattern.
Effizienzhaus Plus	As part of a research initiative an ICT-tool was implemented to monitor energy consumption and use the collected data to optimize energy consumption in the building. The idea is to learn from single houses and use the knowledge on broader level.
E-Jälg	E-Jälg has origins as a municipal initiative for energy management and planning od public premises as well as in housing. The tool is used to monitor energy consumption and can also be used to do benchmarking, analyses and reporting for policy support.
Fortum Fiksu	Fortmu Fiksu is an energy monitoring app provided by the utility company Fortum. In addition to real time consumer energy monitoring and also possibility to some control there will be demand response elements included and the users hot water boiler can be used to balance peak loads.
GEF Vision	GEF Vision provided by Green Energy Finland is an app that can be used to monitor and optimize energy usage with local energy production for example solar panels.
Heating Cadastre Portal	The heat cadaster is used to show the spatial distribution of the heat demand and heat supply structures in the City of Hamburg. The tool provides information and planning basis for actors relevant to energy and urban development.
INKAL System	INKAL system is a tool for real time energy monitoring and control of building energy systems. It is also used to present data in various graphical formats.
Korto	Korteriyhistu.net is a portal for billing in many different buildings in Estonia, thus it includes energy usage information of many buildings. It can be used to benchmark a buildings consumption by comparing with others.
Loxone	Loxone is a holistic home automation system which can monitor and control several of the household appliances and also the energy consumption.
Nachbarschaft-Werk	The tool visualizes energy usage in the area on an interactive map. The map includes information from different sources and levels and enables the user to plan different energy efficiency measures in their building and receive feedback if these measures are economic, if they are in line with existing city plans and what funding is available for their implementation.
Optiwatti	Optiwatti is used to control and monitor the energy usage of different energy consuming systems for example room heating, boilers, heat pumps and car charging. The tool also monitors conditions such as temperature and CO_2.
Smappee Energy	The main purpose of the tool is to monitor energy use to determine which appliance uses the most energy and generates the largest energy bill expense. Depending on which accessory is included with the main monitoring system, there is also the possibility to remotely control the operation of the appliance using an application.
Smart Heating App	The main purpose is to monitor how the heat pumps are working in the buildings energy system. Additionally, there is information available of the conditions in the building.
Smarticipate	Smarticipate is a platform where exchange of ideas can be initiated between citizens and the local council. The platform should make open data available in an understandable format and thus use it as a tool for optimizing planning processes. Through the platform the citizens can submit ideas for the development of their neighborhood.
Talotohtori	Talotohtori service is offering three options for building energy management; Optimizing energy efficiency, maximizing indoor comfort and optimizing building maintenance.
TERMIS	Termis is a energy network management software designed for optimization the use of energy through demand response and demand forecasts.
unnamed	This tool is under development by Örensundskraft and it does not yet have a name. The main characteristics are monitoring, analyzing, benchmarking and reporting of energy usage.
Wattimaatti	Wattimaatti is an application provided by Finnish Utility Company Tampereen Sähkölaitos. To tool can be used to monitor dwelling energy consumption.
ZuluGIS, ZuluThermo	ZuluGIS, ZuluThermo etc. are Russian based application that can be used to monitor and control energy usage on a district level. It can also be used to support reporting, investment and financial planning. It also supports energy auditing procedure on district level.

Source: Author's own visualisation (2019)

Table 3. List of collected ICT-tools, the representing location and key feature of each tool

Name of the tool	Location	Key feature
AMI System	Poland	Energy reporting and benchmarking
DOMATIQ	Poland	Energy reporting, tariff simulations, control based on historical data
e-elering	Estonia	Energy reporting and benchmarking, smart grid
Eesti energia mobile app	Estonia	Consumption planning based on hourly prices
Effizienzhaus Plus	Germany	Citizen involvement platform
E-Jälg	Estonia	Energy reporting dwelling level
Fortum fiksu	Finland	Energy monitoring and demand response
GEF Vision	Finland	Controling building consumption for optimal way with solar panels
Hamburgs Heating Cadastre Portal	Germany	Communal design database
INKAL System	Poland	Real time energy monitoring and control
Korto	Estonia	Energy monitoring, benchmarking
Loxone	Austria	Holistic smart home management
NachbarschaftWerk	Germany	Energy usage visualization for benchmarking
Optiwatti	Finland	Controlling building conditions and systes
Smappee Energy	Belgium	Appliance level energy monitoring
Smart Heating App	Finland	Energy monitoring in heat pumps
Smarticipate	Germany	Platform for citizen participation on city planning
Talotohtori	Finland	Monitoring and controlling, demand response options
TERMIS	Poland	Energy network management
unnamed	Sweden	Energy network management
Wattimaatti	Finland	Energy reporting dwelling level
ZuluGIS, ZuluThermo,	Russia	Energy auditing on district level

Source: Author's own visualisation (2019)

The origin and maturity of each tool is presented in Table 4 The majority of the tools are from commercial origins but there are also a few tools provided by utility companies. In terms of maturity, nearly all the tools have been developed and implemented only during the last few years. On the other hand, many of the tools have been widely implemented and have already established themselves into the market. Table 4 provides a suggestion as to which AREA 21 ICT-tool could be influenced by the good practice example due to feature similarities (refer to section 3.1). Most of the tools appear similar to tool category number 1 (holistic / dwelling), however closer examination reveals that it is too simplistic to force a tool into just one category and many tools have features from more categories than just one. For example, few tools were reported to fit into all 3 categories. For this reason, this Report focuses on the tools' features and less on the category.

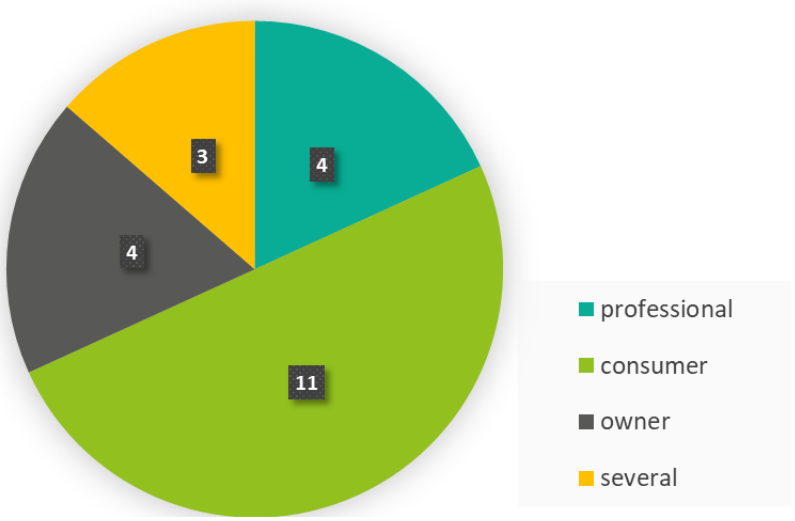
Table 4. The origin, maturity and reported category of each tool

Name of the tool	Origin	Maturity	Category reported
AMI System	Commercial	In use since 2017	Holistic / Dwelling
DOMATIQ	Commercial, (EU-project)	In use since 2010, many different types of buildings	All 3 cat.
e-elering	Utility company	Since 2017	Holistic / Dwelling
Eesti energia mobile app	Utility company	More than 20 000 users	Holistic / Dwelling
Effizienzhaus Plus	Government	Model project (since 2015)	Holistic/Benchmarking
E-Jälg	Municipal initiave	Since 2012, 14 expert users	Benchmarking
Fortum fiksu	Commercial	3000 installed systems in Finland	Dwelling/Energy circle
GEF Vision	Commercial	Dozens of projects in Finland	Dwelling/Energy circle
Hamburgs Heating Cadastre Portal	Government	Continous improvement and adaptation	Energy circle/District
INKAL System	Commercial	Widely used	Holistic / Dwelling
Korto	Commercial	10 years, 2886 buildings	Benchmarking
Loxone	Commercial	Company founded 2009, worldwide	Holistic / Dwelling
NachbarschaftWerk	Government	On going project from 2016 to 2019	Benchmarking
Optiwatti	Commercial	Founded 2013.	Holistic / Dwelling
Smappee Energy	Commercial	Developed 2012, available in 93 countries	Holistic / Dwelling
Smart Heating App	Commercial	Couple of years, 37 buildings	Benchmarking
Smarticipate	EU-project	On going project	
Talotohtori	Commercial	Since 2010...2015, hundreds of buildings	All 3 Cat.
TERMIS	Commercial	Many years of experince	Energy circle/District
unnamed	Utility company	In development	Energy circle/District
Wattimaatti	Utility company	Several years in use in	Holistic / Dwelling
ZuluGIS, ZuluThermo,	Commercial	Since 1990, more that 400 cities in Russia	Energy circle/District

Source: Author's own visualisation (2019)

In Figure 2 the distribution of the intended user of the tools is shown. Many of the tools are mainly consumer-oriented. However, it is difficult to discern between consumer and building owner, and so in some cases consumer-oriented tools are also tools intended for the building owner. A few professionally oriented tools were also identified.

Figure 2. Distribution of intended user of the tool



Source: Author's own visualisation (2019)

4.2. The qualifying features of the tools

Table 5 shows how each reported tool meets the qualifying criteria. This table can be used to pin point those tools that may be worth a deeper examination and thus useful for the development of the three new AREA 21 ICT-tools. The list of qualifying criteria is shown in Table 6.

Table 5. Qualifying features of each reported ICT-tool. (For explanation of each criterion refer to Table 6).

	Qualification criteria														
Name of the tool	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
AMI System	y	s						y			y			y	
DOMATIQ	s	y	y		s	s		y	y	s	s	s	y		
e-elering	y							y						y	
Eesti energia mobile app	s	y		y				y	y	s	s			y	
Effizienzhaus Plus	y	s	y	y	s		y	y	y	y			y	y	
E-Jälg	y	y	y		y		y	y						y	
Fortum fiksu			y					y	y			s	y	y	
GEF Vision		y	y	s				y	y			y		y	y
Hamburgs Heating Cadastre Portal		y	y			y								y	
INKAL System	y	s	y					y							
Korto	y		y	s	y	s		y						y	
Loxone	y	y	y	y	s		y	s	y	s	y	y	y	y	y
NachbarschaftWerk	y	y	s	s	s	s		y	y	y				y	s
Optiwatti			y	s				y	s	y			y	y	
Smappee Energy	y	s	y	y			y	y	y	y	y	y	y	y	
Smart Heating App	y	y	y				y	y			y		y	y	
Smarticipate	y	y													
Talotohtori	y	y	y		y		y	y	y		y		y		
TERMIS	s	y	y			y		s	y		y				
unnamed	y	y	y		y	y	y	y			y		y	y	
Wattimaatti				y	s		s								
ZuluGIS, ZuluThermo,	y	y	y			y	y		y	y				y	y

Source: Author's own visualisation (2019)

Table 6. List of qualifying criteria

1	The tool engages user to a long term involvement
2	The tool is used to supplement energy planning
3	The tool combines data from different sources
4	The tool explains how energy is used in the apartment
5	The tool explains how energy is used in the building
6	The tool explains how energy is used in the district
7	The tool supports setting goals or achievements and follows the progress
8	The tool is used for benchmarking and reporting
9	The tool supports energy demand forecast, optimization and controling
10	The tool formulates tailored tips on how to save energy in apartment, building or district level
11	The tool supports energy auditing
12	The tool provides energy consumption data on an appliance level
13	The tool integrates indoor climate (temperature, ventilation rates, humidity, CO2… etc)
14	The tool is particularly informative and easy to use
15	The tool has some form of social media connection

Source: Author's own visualisation (2019)

Figure 3 displays to what extent the good practice tools met the prequalification criteria. Many of the tools are reported to have features such as benchmarking and reporting, tools combining data from different sources and engaging users to long term involvement. Further analysis on these results is available in Section 5 of this Report.

Figure 3. Number of tools that meet each of the qualifying criteria.

Source: Author's own visualisation (2019)

5. Observations

5.1. Holistic system tool

The holistic system tool was described as follows: The holistic system tool measures building energy and water consumption and the conditions in real time. The tool will also give feedback to the user in the form of raw data, performance indicators or graphs. Additionally, the tool should not be seen only as a building level tool but as a tool where the tenant can see the consumption or conditions on an apartment level.

Based on the received reports, several of the identified tools were considered to have similar characteristics as the holistic system tool. Further examination reveals that many of the tools do measure energy consumption of the apartment and also the conditions. However, the reports do not reveal too many features which would engage the user in the long term. Only three tools have been reported to have a connection to social media.

One of the focuses in the development of the holistic system tool is user engagement and so social media connectivity is considered an interesting feature to investigate. For this reason, tools such as Smappee and Loxone are very interesting examples to look further. Loxone was reported to have a social media connection and both of them were reported to measure and control energy usage at an appliance level. Those two tools are also the ones that met the most pre-qualification criteria and seem very comprehensive ICT-tools for dwelling level energy management. Another interesting example was the tool from Green Energy Finland (GEF Vision), which also had social media connection.

Goal setting and progress tracking are other features that can be used to support user engagement and participation. The good practice tools Smappee, Optiwatti, Effiziezhaus Plus and NachbarschaftWerk can be examined further on how to successfully build in these features.

5.2. Innovative online tool

The innovative online tool was described as follows: The innovative online tool will guide energy users through the energy auditing procedure. The tool will gather data on the energy consumption and produce energy consumption reports based on the data. The reports will also suggest potential energy saving changes in the behaviour of the tenant.

Many of the good practice examples met the prequalifying criteria number 8: "The tool is used for benchmarking and reporting". In many of the cases the tools collect energy consumption data and compare it with other similar buildings and thus they were considered to meet this criterion. However, it seems that not too many tools will analyse and process this data further into actionable items such as energy saving suggestions or reports supporting energy auditing. However, one particular example may be very interesting in this respect. The German project InnovationCity Ruhr launched a tool called NachbarschaftWerk. This tool helps to visualize an area's energy usage using an interactive map comprising information from different sources, building scales and enables the user to plan different energy efficiency measures.

Only a few tools were identified that provide a feature which would formulate tailored tips on how to save energy. For example, Smappee and Optiwatti were tools that have this feature and Loxone and Domatiq were reported to meet this criterion at least to some extent. Tools with a combination of features like benchmarking and energy auditing support also provide useful insight into development for further examination. The tools that have this combination include for example Smappee, AMI system, Smart heating app and Talotohtori.

5.3. Energy improvement circle tool

The energy improvement circle tool was described as follows: The tool will monitor and manage energy consumption and production of an energy network. The tool will be able to combine management of local energy production, heat recovery systems and energy consumption into one energy improvement circle. Demand response solutions will provide a platform for promoting reasonable energy consumption and new culture of energy usage.

Although many of the tools had limited or no similarity to the energy circle tool, other features of value could be considered for its development. For example, a few tools explain how energy is used at a district level including Hamburg's Heating Cadastre Portal and Termis. There were also a number of tools which support demand forecast optimisation and controlling such as Fortum Fiksu, GEF Vision, Domatiq, Eesti Energia mobile application and Talotohtori.

In particular a combination of features such as provided by the Termis tool which includes district level energy management and demand forecast optimization may be interesting in development of the energy improvement circle tool. The GEF Vision tool could also be used to guide the development of optimizing local electricity production with the consumption.

Conclusion

The background research and energy ICT-tool survey undertaken provided some valuable insight to support the development of tools for the AREA 21 project. Key observations from the good practice tools are summarised below.

1. Most existing energy related ICT-Tools are not purposely built for energy planning

The majority of good practice tools are not purposed for energy planning, instead they provide a stronger focus on energy reporting, invoicing and in some cases energy management. However, tools that report energy consumption in various forms can be used to support energy planning. These kinds of tools can be found in large numbers, but they are hardly energy planning tools by design.

2. User participation functionality is uncommon

Many tools collect data and represent it in a graphical format, however only a few tools have any link with social media or attempt to initiate the user into active participation. The background research revealed that a tool may have better success in energy reduction if it was able to initiate or otherwise maintain engagement.

3. A holistic compilation of data could make the application more engaging

Although many of the tools reportedly combine data from different sources it seems that not many tools in the collection seem to combine data from many different service providers into one holistic pool of data. A tool that could take a holistic approach and combine reliable real-time data on conditions and provide the user with tangible information and to see regular new updates, could help sustain user interest for longer.

4. Interface usability is important for initial take-up and interaction with the tool

The background research revealed that usability and understandability of the tool holds a significant value in the development of ICT-tools. The end user is likely to already have some barriers when adopting a new tool and the tools usability should not provide another.

5. Most tools on the market are purposed for the dwelling or building Level

Many of the tools identified are purposed for dwelling level or building level energy monitoring and very few are for district level. This may be due to the fact that energy consumption is very much an individual concern and network management is usually undertaken by professional entities with tools designed for purposed user functionality without citizen participation.

References

Buchanan, K., Russo, R., Anderson, B. (2015). The question of energy reduction: The problem(s) with feedback. Energy Policy 77 (2015) pp.89-96

Bull, R., Lemon, M., Everitt, D., Stuart, G. (2015) Moving beyond feedback: Energy behaviour and local engagement in the United Kingdom. Energy Research & Social Science 8 (2015) 32-40

Burchell, K., Rettie, R., Roberts, T. (2016) Householder engagement with energy consumption feedback: the role of community action and communications. Westminster Research

LaMarche, J., Cheney, K., Akers, C., Roth, K., Sachs, O. (2014). Home Energy Feedback Devices, Chapter 1: Home Energy Displays: Consumer Adoption and Response

Annex 1: Questionnaire Template

ICT-based participation tools
Good practices questionaire

Version 1.0- for identification of Good Practices
Date 4.5.2018

Introduction

This questionaire is to be used to collect information on the good practices that can be found of different types of energy management tools. This questionaire is released for the purpose of identifying good practices in ICT-based participation tools. We ask for our project partners to identify at least three good practice tools and fill in the information of these candidates. Additionally we ask for our project partners to deliver these filled questonaires at least once per month until july (may-june-july... three in total).

In the beginning of this questionaire there is a pre qualification section (section number 0). In this section we first describe what are the key characteristics of the three tool categories that are to be developed in WP4. In the beginning we also present some prequalification criteria. The aim of this qualification is to establish the basis for identification by presenting key points which may be the most interesting in terms of the three tools in questions and also to filter out the most interesting cases from the possibly numerous amounts of tools. Use this qualification section as a quide to what kind of ICT-based participation tools may the most interesting ones. Also if there are tools to be found in other areas of life other than energy which could provide useful lessons you could report them also more informally.

When the qualification is established, the further analysis can be made. For this we provide the questionaire sections 1...4 where additional information of the qualified tool can be filled.

Please send filled questionaires to followind adresses: antti.makinen@tamk.fi, kari.kallioharju@tamk.fi

This questionaire was made by GoA 4.1 leader Tampere University of Applied Sciences in cooperation with WP4 leader Tartu Regional Energy Agency.

Definitions of the three tools

In WP4 there is an objective to develop three different types of energy management tools. Here is a short description of these tools:

1.Holistic system tool - dwelling's energy consumption

Measures energy and conditions on an apartment level and provides feedback to the resident in the form of performance indicators. The tool will engage the resident into two-way communication and participation.

2.Innovative online tool - benchmarking tool for housing energy

The primary function is benchmarking of electricity, heating and water heating on house as well dwelling level on monthly basis by reporting and graphical interfaces. Supports in comparative energy and performance analysis, reporting and investment/financial planning. Supports energy auditing procedure on apartment level, building level and district level. Semi-automatic or manual data inputs.

3.Energy improvement circle tool - energy consumer/prosumer district model

Big Data based energy tool monitors and reports energy flows and loads on a district/community, building and dwelling level at hourly, daily, monthly basis. Combines various automatic data inputs for example local energy production, heat recovery systems, energy consumption into one energy improvement circle. Enables demand response, peak load etc solutions. Integrated with the billing system.

0	Qualification criteria
0 a	**For a tool to qualify for further analysis it should match the two key points below.**
The tool is ICT-based	
The tool needs to be at least somewhat similar with at least one of the three tool categories described above	
0 b	**For a tool to qualify for further analysis it should match at least one of the key points below (use checkbox: yes= Y, to some extend = S, no = leave blank).**
	The tool engages user to a long term involvement in energy monitoring or energy planning
	The tool is used to supplement energy planning
	The tool combines data from different sources (multiple databases, manual readings, sensor data, building data… etc)
	The tool explains how energy is used in the apartment
	The tool explains how energy is used in the building
	The tool explains how energy is used in the district
	The tool supports setting goals or achievements for energy consumption and follows the progress
	The tool is used for benchmarking and reporting
	The tool supports energy demand forecast, optimization and controling
	The tool formulates tailored tips on how to save energy in apartment, building or district level
	The tool supports energy auditing
	The tool provides energy consumption data on an appliance level
	The tool integrates indoor climate (temperature, ventilation rates, humidity, CO2… etc)
	The tool is particularly informative and easy to use
	The tool has some form of social media connection

1	Basic information and qualification
1 a	**The name of the tool**
1 b	**The origin of the tool: Initiator, ownership and main motivation** For example: Utility company, academic project, commercial, other… The name of the company/institution and short description
1 c	**Financing of the tool** How the development and current implementation is funded? Description of the funding
1 d	**Further information** How one can get further information of this tool? For example is there a demo version which could be available? Contact details for further information. Short description on how to get more information.
1 e	**The tool category** In which of the three categories (1.holistic/dwelling, 2.benchmarking, 3.energy circle/district) the tool fits the best? (Possibly more than one, or others) Short description on the tool features in regard of the the three tool categories.
1 f	**Qualification criteria: The good practice feature(s)** Why was this tool qualified for further analysis (refer to the prequlifying criteria in 0 b)? Fill in 0b. Describe and elaborate here.

2	Implementation and data management
2 a	**The purpose of the tool** What are the main purposes the tool is used for? For example: Billing, validation, monitoring, control, demand response, benchmarking etc.. Description of the purposes.
2 b	**The level of practical implementation** How long and how widely has the tool been in use? What are the major references? Are the buildings public or private? Short description on the level of practical implementation (widely used/recently introduced/prototype) and references.
2 c	**The scope and level of measurements or data** The scope for example: heat, electricity, water, flow rates (ventilation etc), conditions (Temp., CO2, humidity…) The level for example: district level, building level, apartment level, appliance level Description of the scope and level
2 d	**The source of the data** Does the tool utililize own integrated measurements or does it gather and compile information from secondary sources? Description of the source of the data.
2 e	**Data storage** Where is the data stored: Local server, cloud… etc. Description of where the data is stored.
2 f	**Data ownership and access** Who owns the data? Who has access to the data? Description of the data access and ownership
2 g	**The equipment overview** What kind of equipment is used/needed for the measurements? The types and amounts? Description (not too elaborate is necessary) of the used equipment
2 h	**Measurements accuracy** How detailed and reliable the measurements are? Are they real-time? What is the resolution? What are the measurement intervals? Description of the level of detail and the reliability of the measurements.

3	User experience
3 a	**User profile** Who is meant to be using the tool? Is it a tool for professionals only or for building owners or citizens? Description of the user profile.
3 b	**User interface** What interface is used: Stand alone device, web page, smart phone app... Short description of the interface. Please add print screen of tool.
3 c	**What the user sees** What does the user interface look like: Scalable graphs, alerts, raw data, consumer friendly graphics… etc Does it also have control commands? Does it provide tips or reports? Description of what the tool is like from user persective
3 d	**User engagement** Does the tool engage the user into participation in any way or is the user only passive receiver of information? Are there any two-way communications available? Does the tool have any connections to social media? Description of user engagement.
3 e	**Usability issues and critical feeback** Does the tool have any usability issues (good or bad) reported? Did the tool receive critical feedback from the users? Description of usabilitys issues and critical feedback
3 f	**Tool training and motivation** Did the implementation of the tool require training or motivating of the users? Description of the need for training and motivation and how it was done.

4	Sensors and data collection
	This section needs to be filled only if it is applicable to the tool in question i.e. tool has integrated/original data sources. Also some of the information in this sections may be difficult to obtain. In such cases it is desirable to fill in only the part of the information that is readily availbale or easily obtainable with little effort (for example by short interview etc..)
4 a	**Data ownership contract** Is the ownership of the data contracted somehow? Description of the data access and ownership
4 b	**Data saving** How often data is saved? How long old data is stored/archived? What is the practice of archiving and clearing old data? How large are the databases (for example per flat)? Description of where the data saving and archiving?
4 c	**Sensor performance** What is the distance sensors can send the data? Does the sensor work on batteries or with electricity connection (if batteries, how often they need to be replaced)? What type of connection is used (wlan, bluetooth)? Description of sensor performance.
4 d	**Sensor reliability** How accurate are the readings? How reliably they are working over time? Is it possible for an outsider to read the data of the sensors? Description of sensor reliability?