Energy planning and management **tools**

AREA 21 guide

Tartu, 2020

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About AREA 21 project: AREA 21 addresses challenges on the transition towards low-emission cities and supports cities in the Baltic Sea Region to harness the full energy savings potential of existing structures, to elaborate holistic strategies that integrate sector-based approaches, and to engage energy consumers in strategic energy planning.

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AREA 21 guide

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Introduction

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The urban district approach for climate and energy

To provide wellbeing to citizens in the contemporary urban environment, the society must respond to climate change. All citizens and urban stakeholders have roles to play in climate change mitigation and adaptation. For this long-term commitment and to achieve the stated goals, urban stakeholders should deliver new approaches and agile models for urban energy transition and decarbonization policies. Addressing those challenges, the Nordic urban model is the pioneer in terms of technological innovation in societal contexts and is recognized internationally (Nordregio 2017).

The Baltic Smart City Areas for the 21st Century, the AREA 21 project, focuses on integrated energy planning and cooperative processes at a district level. AREA 21 aims to provide local authorities, energy agencies and other institutions responsible for energy planning with the expertise and strategic tools to plan and implement new solutions for energy efficiency in urban districts.

To achieve this, the project developed new ICT tools for implementing energy efficiency measures, optimizing energy consumption and benchmarking the progress in the Energy Improvement Districts of the AREA 21 project. This guide presents the development and implementation of three tools besides other best practices and applications in the field of participatory ICT-based energy planning and management.

AREA 21 builds on holistic, cooperative, participatory and educational domains, and we focus here in particular on promoting the use of contemporary smart technologies to facilitate the energy planning process, testing new forms of public participation, raising awareness about the individual and collective energy consumption and promoting behaviour change.

The Energy Improvement District (EID) concept is an innovative system approach for low carbon-emission urban districts that promotes a cooperative model of urban renewal and involves citizens and businesses. The concept, which addresses energy-transition challenges, has been tested and implemented at the urban district scale in Tartu, Kohtla-Järve, Tampere, Helsingborg, Lublin, Hamburg and St. Petersburg.

Objectives of the guide

The objective of the project and this guide is to explore and exploit the potential of ICT-based tools to involve citizens, tenants, owners and technical experts in the planning and implementation of energy efficiency measures.

It explains an approach that the AREA 21 partners took to develop energy management tools; the scope and the methodologies that may be employed in carrying out such energy monitoring systems and applications; and how to use them and inform policy and decision making. Similar to the project concept, it emphasizes the values, strengths and techniques of participatory energy planning in cities. This guide is not intended to be prescriptive but explores the development path and functions and presents lessons learnt from the three AREA 21 tools:

- **The benchmarking tool for building energy**, called the 'Energiamonitor', developed in Tartu, Estonia.
- **An energy monitoring tool for real-time monitoring** of energy consumption and indoor conditions, developed in Tampere, Finland.
- **A demand-response tool for identifying and quantifying smart energy solutions**, developed in Helsingborg, Sweden.

These three new tools have been developed in the framework of the ICT tools work package in the AREA 21 project framework, dedicated to citizen involvement in energy planning and operationalisation. The reader will be introduced to the key features and qualities of the tools in order to acquire additional information and can consult original sources via the AREA 21 project homepage.

The main objectives of the guide on energy planning are:

- To promote the development of energy management and planning concepts, tools and applications to underpin energy planning at the urban district scale with the primary focus on buildings and the housing sector and deploying the participatory approach from the citizens' and end-users' perspective.
- To offer the key points in developing the participatory energy planning tool to illustrate how the development process is established, providing system graphs of ICT tools and timelines of tool development, testing results, monitoring reports of energy savings, training users and engaging citizens.
- To inspire urban stakeholders and provide advice on developing and implementing the participatory energy planning tools.
- To assist end users in the optimisation of energy usage and selecting energy efficiency measures.
- To encourage a greater degree of integrity and consistency in terms of the tool development and end-user benefits that are ultimately required to assist with the energy transition and decarbonisation in the urban energy systems and urban districts.

Using the guide

The guide follows a similar structure to the ICT tools work package of the AREA 21 project in order to clearly differentiate between the background study and external best practices of energy planning, and the development and application of the AREA 21 tools. Also, the guide seeks to avoid repeating participatory approaches and practices, instead directing the reader to the AREA 21 guides and policy documents which indicate the scope of participatory energy planning and the range of issues that project explored and covered in order to deliver and advance the energy improvement district approach. Those documents are as follows:

- The position paper "Cooperative energy planning on the district-level: Recommendations on policy improvements for energy efficiency of BSR cities and regions".
- Guidance on cooperative energy planning at the district level.
- The process model for the cooperation of local and regional authorities, energy utilities and public property owners in energy efficiency implementation at the district level.

Chapter 1 provides the introduction. Chapter 2 outlines the concept of urban energy planning using ICT tools, innovative models and good practices in energy planning, the role of ICT applications in the field of urban energy and support systems on energy efficiency to identify the need for new applications. Chapter 3 covers the development of three AREA 21 tools in depth, setting the wider context and framework in providing the urban context for the pilot energy improvement districts, the smart city Tampere and the sustainable energy plan of Tartu. The final chapter, recognising the dynamism of the climate policy scene, summarizes innovative and positive approaches and the evidence to support new participatory ICT-based energy planning and discusses how to adopt new concepts, tools and applications, drawing on examples of good practice to illustrate what is meant by the guide in relation to the need for flexibility. At the end, key messages are offered on the development and use of energy-planning tools.

This practical guide is not supported by technical appendices. Instead, it incorporates cases and infographic plates throughout to illustrate key elements and points in tool development. Each of the three tools should be assessed on its own qualities, functionalities and merits based on local needs, environments and circumstances. However, if local authorities and housing associations are considering applying the AREA 21 tools, they should directly approach institutions and experts and may in some cases be required to consider a simplified application of the tools. Experts and developers involved can provide a more detailed guide on how to adopt the AREA 21 tools for their settings. Alternative approaches in energy planning at the urban district scale are equally relevant and justified as the guide gives ideas and hints for interpreting how urban energy policy can be supported and how energy consumption can be optimized in individual decisions by the readers of this guide.

Who should read the guide?

This guide is intended to assist a wide range of urban stakeholders in sharing knowledge on ICT-supported energy planning tools and developing energy applications. It will assist housing maintenance and municipal staff, urban engineers, and energy operators preparing for ICT-supported smart city applications. It is also intended to support housing associations, neighbourhood societies, urbanists and citizens in their daily urban practices and energy consumption. The guide demystifies some of the ICT modelling and testing in such applications. For those project partners and subcontracting developers involved in developing and testing the AREA 21 tools, Chapter 3 will review and synthesise what has been done in the framework of project.

2

Innovative models and good practices of energy planning

Antti Mäkinen
Antti Roose

Urban and energy planning using ICT tools

This chapter introduces ICT-based urban energy planning approaches and practices highlighting the most relevant themes and issues for supporting ICT system deployment and citizen participation. It also relates to the mainstream uses and key functionalities of such tools and applications. The chapter demonstrates the best practices from the Baltic Sea Region and guides urban actors in choosing among the various approaches and applications for energy management, monitoring and benchmarking. In this guide, buildings and related energy infrastructure are the scope.

The digital revolution has brought together a multitude of digital and technical advancements that have accelerated urban management, planning and transformation. Sustainability, climate and energy are a top priority for cities. In short, both sustainability and technological innovation are often enabled by ICT. Depending on the purpose of energy users, there are plenty of ICT tools that enable energy management, planning, monitoring and benchmarking (Petrichenko et al. 2016). New technologies, processes and business models relating to the renewal of urban districts and their building stock, including comprehensive renovation of buildings, are supported by contemporary ICT and data management. Raw urban and energy data needs to be converted into knowledge. Obviously, the analyst as well the user has certain restrictions and limitations related to data, system infrastructure and practical uses. Over the last two decades, green building and sustainable building have boosted the usage of ICT tools to evaluate the energy performance of the building and to set sustainable operations. It also provides the value of green innovation due to the need to differentiate over mainstream, ordinary buildings and former technology. The EU promotes national databases which can be used for compliance checking and for producing statistics on the regional building stocks. Measures are required to allow data to be gathered on the measured or calculated energy consumption of buildings and to make available aggregated anonymised data (EU 2019).

In recent years, 'smart city' and 'big data' have become buzzwords which drive progress in cities. In regard to citizen participation, smart cities remain rooted in pragmatic and instrumental discourses and practices rather than those of social rights, social-spatial behaviour and the common good. Cardullo and Kitchin (2018) underline the citizen-focused approach and deploying the smart citizenship concept.

Various tools, applications and software assess energy performance, energy efficiency and design quality of buildings and urban districts (Oregi et al. 2015). The assessment tools of sustainability provide a broad spectrum of performance indicators, from energy, the climate and environmental impact to health, the user and living quality. Another dominant cluster of ICT-based tools provides decision-support tools designed to help cities identify issues and problems in urban energy management, to evaluate improvement and cost-saving potential, and to prioritize projects and actions for energy efficiency intervention. Usually, transport, buildings, the water system, public lighting, waste, and power and heat are covered by those tools in providing the evaluation, quality merits and evidence for policy-making, specifically in this context for the integration of green buildings with the smart city concept. The projects develop simple and robust energy assessment tools, for example, Excel sheets, to provide open access to public users. Recently, climate policy-driven tools have been developed to stimulate the transition towards energy-neutral urban districts (Tozer and Klenk 2019). Those tools enable backcasting and forecasting to serve municipal decision makers, urban planners, real estate developers and energy operators. Real-time energy management and monitoring tools provide analysis for increasing energy efficiency, reducing energy use and increasing the share of renewable energy in a city.

Recently, building information modelling (BIM) has been adopted in construction engineering and applied in new building stock as well as in retrofitting (Carvalho et al. 2019). BIM software is used by individuals, businesses and public institutions who plan, design, construct, operate and maintain buildings and physical infrastructures. BIM enables the functional characteristics of a building to be controlled—in the current context energy-related functions—in considering design decisions within the realities of building operation. If many buildings are integrated into the BIM, it can serve as district modelling for professionals.

Traditionally, engineers and planners have assumed people are more or less the same. Currently, the recognition of the diversity of people and lifestyles opens up a huge area of urban debate. Incorporating citizens' insight and input, increasingly significant attention has been directed at citizens' participation in urban planning and transition. Energy is related to a sustainable, smart and digital way of living, not only to engineering and technology. Every household pays monthly utility bills and every consumer's situation is slightly different. Every person desires to reduce their bill. Implementing user-friendly ICT tools supporting sustainable urban living, in this case improving energy efficiency and saving energy, is a complex task for urban managers, ICT developers and engineers.

The good practices of using ICT tools

ICT tools for energy planning are widely used in the Baltic Sea countries. The AREA 21 project collected a series of good practices to explore the needs, development, and usage of ICT tools in energy planning. The background research in this field is also summarized below.

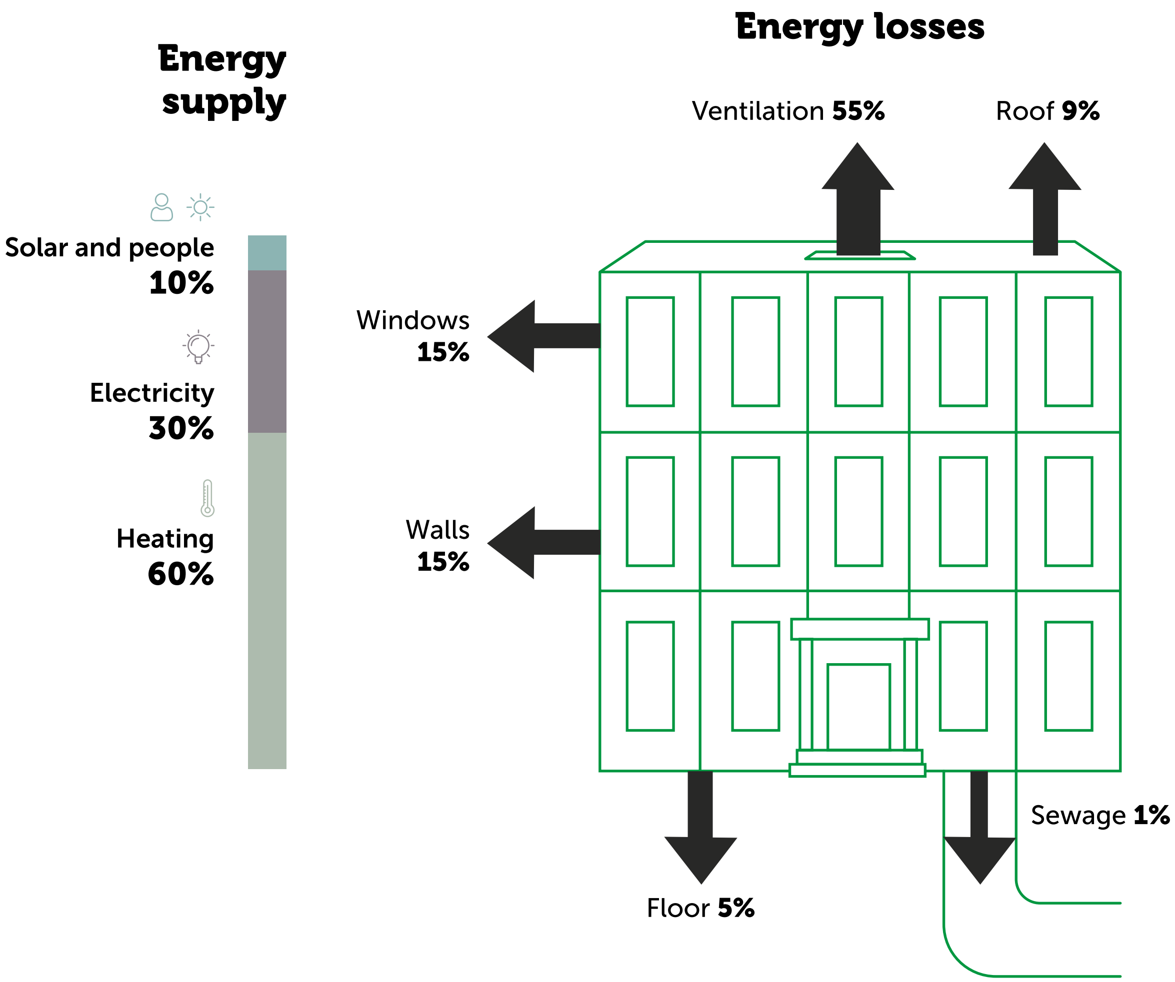
Citizen participation in energy planning

In short, energy as a concept and as a consumable commodity is viewed by ordinary citizens, that is, energy users, as something that may be somewhat difficult to understand. Alternatively, their interest is limited by simple functionality: 100% security of the energy supply is at the household level or related to the energy bill and the cost of energy. For instance, there are many cases where residents of a building were offered a free energy-monitoring device for their home premises, but many still opted not to take it, ignoring the advice of the energy auditors. While it is widely documented that energy monitoring has an effect on people's daily behavior and results in energy savings, the effect is not long lasting because energy monitoring fades into the background of everyday life and routines as more important duties take priority.

The general interest among citizens in monitoring energy usage in their private homes varies. There is a need to increase citizen awareness on energy usage and planning. Recent developments in urban planning forecast an emerging arena for a participatory approach that includes citizens at the household level. Some groups that have stronger reasons and commitment may pay attention to the technical aspects. For example, pilot projects have been conducted where citizens, seeking quick solutions to their urgent problems, use an online platform to report malfunctioning equipment (lights, etc.) or infrastructure errors.

Figure 1: Energy balance of a building.

Energy flow is different in each building. The example shown here could represent a typical office building, whereas as a typical apartment building has quite different distribution of energy flow. How and where energy flows can be determined with measurements. In order to gain synergy in urban district the combined houses jointly have a more beneficial, energy and cost efficient effect that could be obtained by adding up and integrating solutions of individual houses.



In order to take citizen participation further in the field of energy planning, **two new factors should be implemented in this process, the first being educational and the second motivational.** Citizens need to have some basic understanding of the concept of energy and energy as a commodity before they can be expected to take part in energy planning. They also need to be motivated to learn about energy and how they can participate in planning its use. This is where ICT tools step in.

ICT tools can help to lower the barrier of citizen participation by targeting the educational and motivational dimensions. The background research explored the following (Buchanan et al. 2015; Bull et al. 2015; Burchell et al. 2016). ICT tools should be developed and operationalized with straightforward usability and clear understanding for citizens so that they are able to overcome the initial barrier in adopting new technologies. Experts who develop tools which target professionals should also consider the fact that this information can be used by ordinary people, so it should be presented in a form that is easily understood and applied. Consequently, raw energy engineering data needs to be transformed into consumer information.

Additionally, ICT tools should preferably take a holistic approach. Basic information on energy consumption may become redundant without information about what the energy was used to accomplish. For example, the addition of information on indoor and outdoor conditions (temperature, CO_2, etc.) can help a user understand the cause and effect of energy consumption because much of the energy use in buildings is meant to maintain these living conditions. In addition, presenting energy consumption data in aggregated form can help a user deduct what role each appliance or function plays in overall energy consumption.

Figure 2: How do we activate citizens? The Tampere case.

General stakeholder engagement process for a smart city. Effective citizen engagement ensures understanding of a smart city program and its strategic aims and objectives.

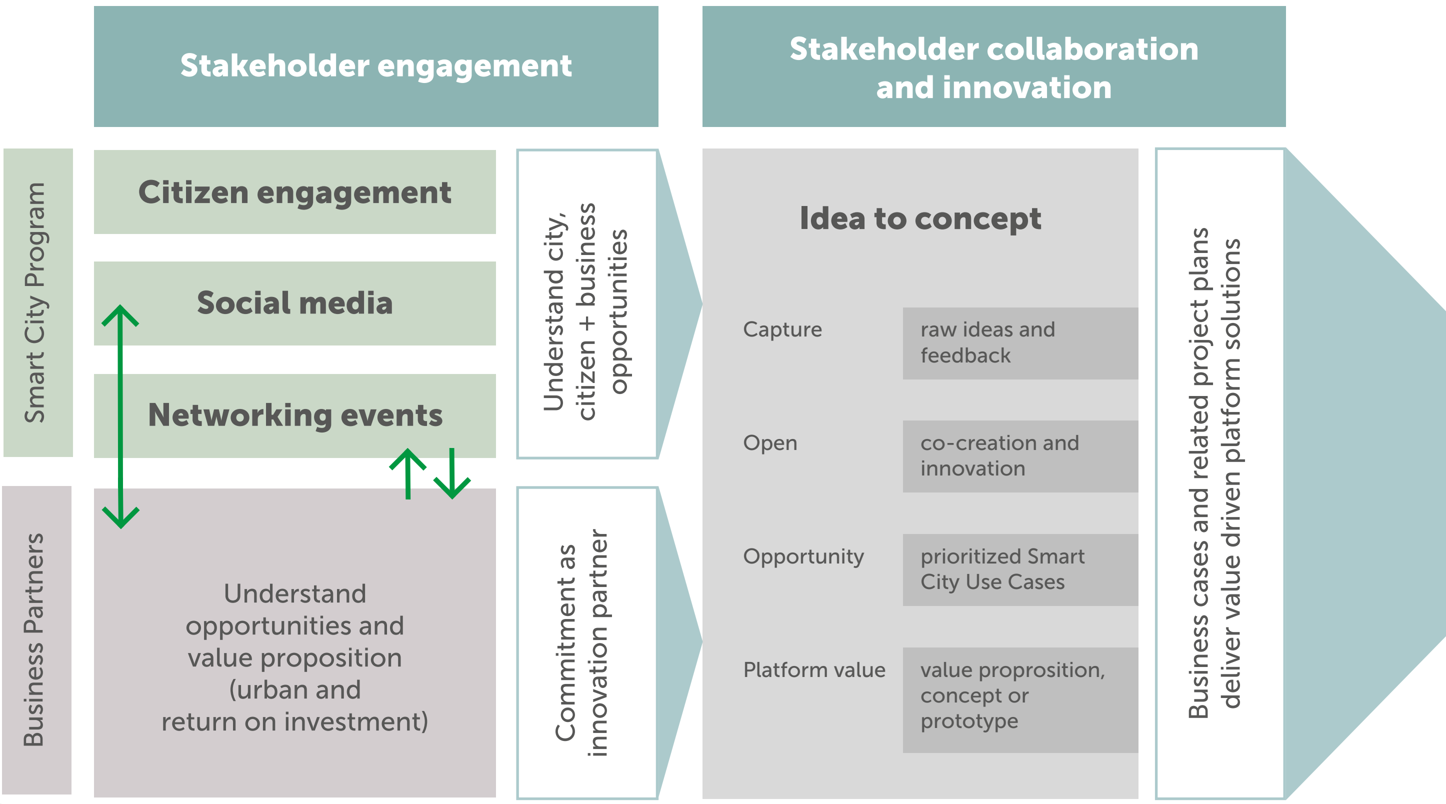
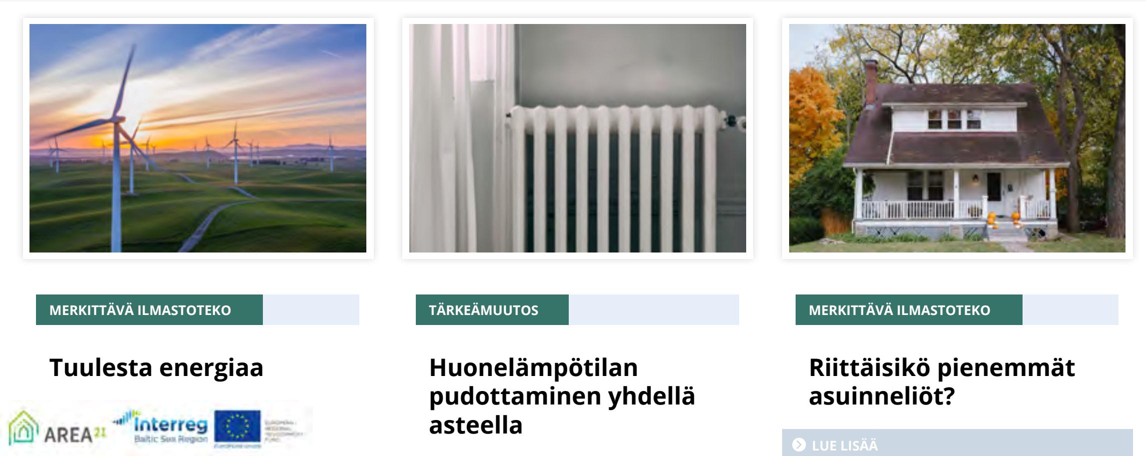
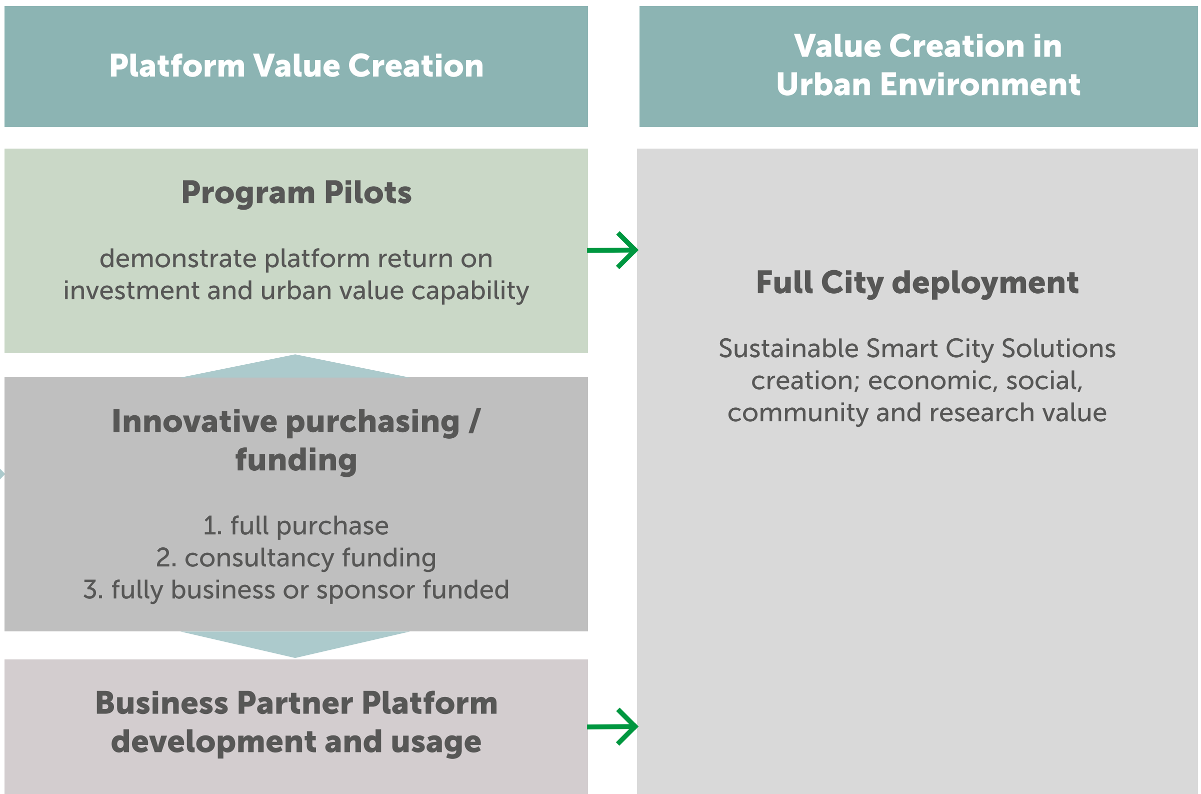


Figure 3: Climate Hero campaign for the citizen activation in Tampere.



- ”Climate hero” web page on the internet, where you will find tips for sustainable living in Tampere.
- Local tips about sustainable transport, eating, living, energy and consuming.
- Ilmastosankari.fi (only in Finnish for now)



Nick Cotton, 2019. The Smart City, Cookbook, A Recipe for Successful Smart City Programs, City of Tampere

Good practices of tools

The main objective of the good practice report on ICT tools in energy planning was to analyze good practices in BSR countries. Some international cases were also analyzed. The method used to collect these cases consisted of a set of criteria that the tools should meet. These criteria guided partners to find the desired examples in their respective countries. The search was directed, on the one hand, to find similar tools that were being developed in the AREA21 project and, on the other hand, tools that would have a focus on citizen participation. In total, the experts explored 22 energy tools as shown in Figure 4. Several tools in the sample measure, collect and analyze historical data on buildings or dwellings and present them in different forms. Some of the tools go into more detail than others, and some tools contribute to the control and automatization of energy systems in buildings. Some tools benchmark the use of this historical data to make comparisons with other similar types of buildings that also use the tool in question. The tools are designed for energy network management and optimization.

Figure 4: List of analyzed ICT tools and applications.

Data tools
Monitoring, reporting, benchmarking

Eesti Energia mobile app (see on the next page)
E-Jälg
Wattimaatti
Nachbarschaftwerk
E-elering
Korto
Fortum Fiksu

Building automation systems
Advanced user engagement functionalities

Smappee Energy
Optiwatti
Smart Heating App
Talotohtori (see on the next page)
Loxone
Domatiq
GEF Vision
INKAL system

Participation tools
Direct citizen engagement in energy planning

Smarticipate
Effizienzhaus Plus

Energy network management
Management, demand response, prosumerism

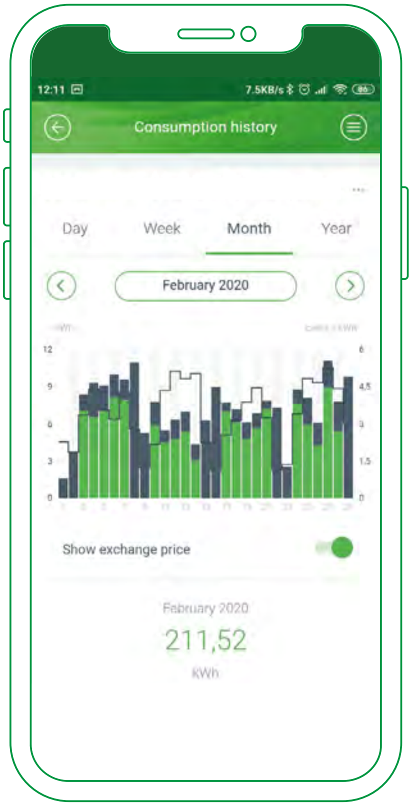
TERMIS
Hamburgs Heating Cadastre Portal
AMI System
ZuluGIS, ZuluThermo

Figure 5: Featured applications.

Eesti Energia

https://www.energia.ee/era/tark-kodu/mobiiliapp

15000 monthly users (2017)

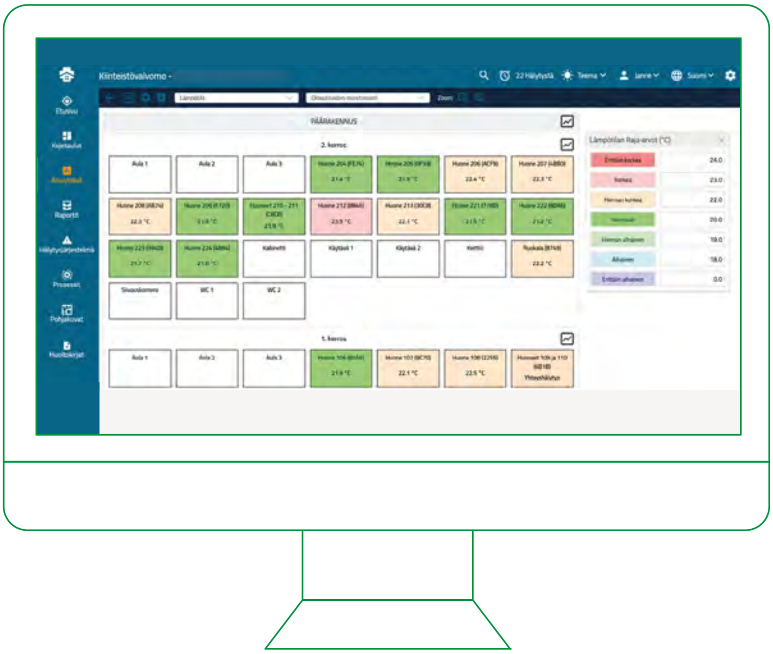


The mobile application of Eesti Energia supports smart energy consumption. All home and business customers can follow their electricity consumption points using this app. It also provides also information on contracting and invoicing. Hourly, daily, monthly and annual electricity consumption can be displayed in in-depth analysis of electricity consumption. The app shows the exchange prices for the next day's electricity. When the user opts for hourly pricing, it directly supports electricity usage planning for more cost-efficient and sustainable temporal patterns. The notification enables messaging if the electricity consumption is significantly different from normal one.

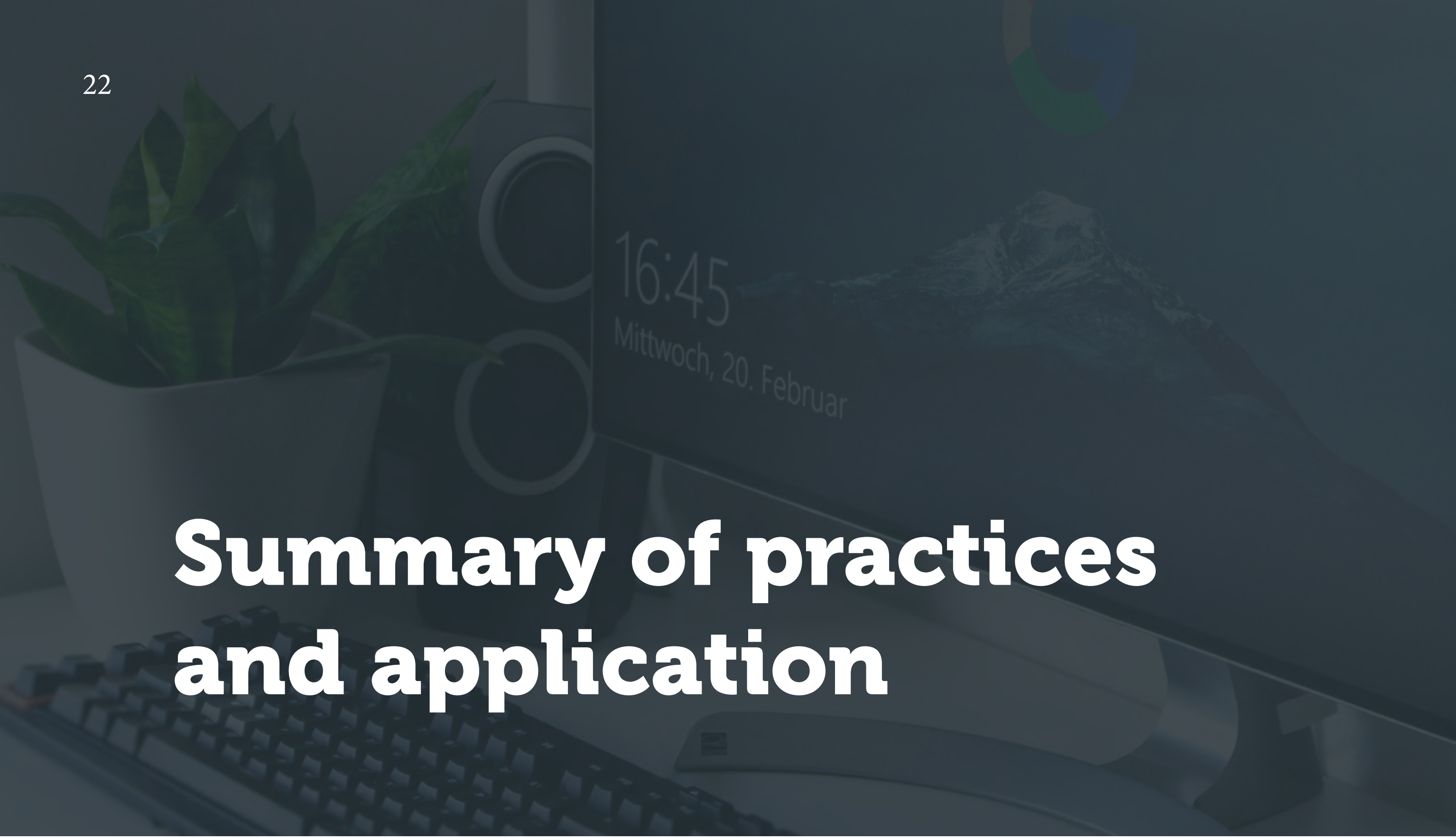
Talotohtori

https://www.talotohtori.fi/

500—1000 monthly users (2019)



Talotohtori is an example of a building automation management system that measures and controls building energy consumption and indoor climate. It can be integrated to buildings equipped with devices of different manufacturers. The user has an option to modify user interfaces and choose differents kinds of graphs and visualisations.



Summary of practices and application

This study on good practices for ICT tools in energy planning concludes that while there are tools that aim to encourage the user's energy awareness through participatory techniques, such tools are not yet widely distributed. Additionally, the development of new tools that have participatory features is emerging on many different fronts, but large-scale breakthrough of these new tools into people's everyday lives is still yet to come.

New tools for energy planning with a citizen participation function which intends to be widely used in a commercial sense and by the public should integrate user support in relation to their educational and checking functions. The tool should be able to provide information about how people's choices impact energy consumption and their everyday behavior or on making energy-related investments. One important factor in energy use in the future is not only how much energy is used, but when it is used and how big the load is at a given moment. This challenge should be tackled by demand-response systems and tools. For citizens to be able to understand the concept of demand-response and their opportunities to contribute in it, they need a tool which can be used to clearly and transparently pinpoint how much energy each of their actions consumes and how big the load is.

The essential deficiencies of ICT tools are as follows:

1. The barrier between data and the tool: the tool should enable an automatic or semi-automatic data entry mode.
2. The barrier between information and user: given visualized information tends to be highly specialized and professional. Providing information in a simple and understandable way to citizens is a key.
3. **The barrier between tool and user:** tools are developed by professionals for professionals. Citizens as end users without any specific skills should be able to use the tool.

In addition, the background research on publications and exploration of good practices for ICT tools in energy planning concludes the following:

- The majority of energy-related ICT tools are not purposely built for energy planning.
- Citizen engagement functions are uncommon.
- Holistic compilation of data could make the application more engaging.
- Interface usability and attractiveness are highly important for the user's initial take-up and interaction with the tool.
- The majority of tools are designed for the dwelling or building level.

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3

The AREA 21

ICT tools

3.1

Benchmarking tool

Tartu, Estonia

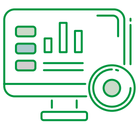
emonitor.trea.ee »

Marten Saareoks

emonitor.trea.ee

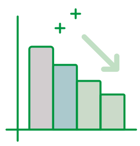
Introduction

Energiamonitor *(emonitor.trea.ee)* **is a tool for energy monitoring, analyses and reduction.** It was developed in cooperation with Tartu Regional Energy Agency's energy experts and NewTime's IT designers. The tool stores and analyzes a building's energy consumption and costs, thereby enabling the user to get a better understanding of the building's needs and savings potential. The application also has a built-in option to contact an energy expert for consultation about energy efficiency or building reconstruction.



Monitoring dashboard

Energy labeling



Energy performance

Benchmarking

Sharing

The application is intended to be used by owners or managers or users of real estate who are interested in energy consumption and savings at their site. Only the user's e-mail address is required for use of the application.

The user interface of the application supports four languages:

- Estonian
- Russian
- English
- Polish (special interface)

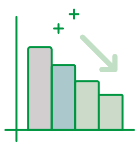
Energiamonitor functionalities

Dashboard: data input and monitoring

Entering energy data in energy units and in euros. The dashboard has bar graphs for a timeline with a monthly and yearly view. The extra line graph is for heating data normalized by degree days.

Energy labeling

Core for the application's modules and calculation. Every user can track their building's calculated energy label and as soon they entered have one full calendar year of data.



Energy performance upgrade/renovation module

Different energy-saving measures can be tested to analyze a site's energy usage. The exact list depends on the set-up site – list of possible options:

1) renovation to achieve energy class A, B or C;
2) installation of solar panels;
3) changes in consumer behavior.

Benchmarking module

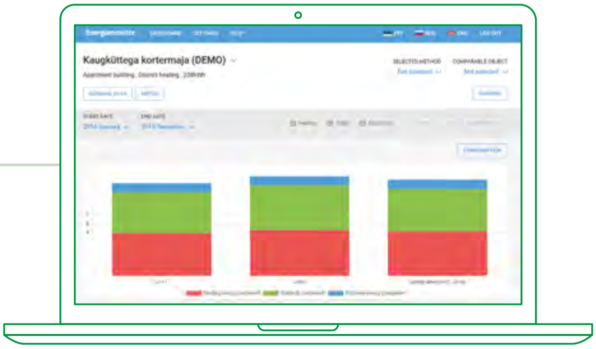
Building can be compared with the average of all the same type of objects and with an individual object manually chosen based on similarity factor.

Sharing module

Objects can be shared in different ways. Multiple admins or viewers can be assigned for objects, and an option to export data to an Excel file is included.

Monitoring dashboard

Energy labeling



Energy performance

Benchmarking

Sharing

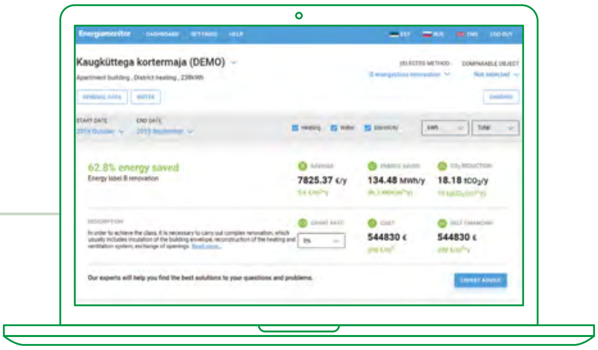


Plate 1

Energy Improvement District

Kalda tee, Tartu

Anne tn 55

< 2017
189
kWh/ (m²·a)

E

Kalda tee 10

2010
201...250
kWh/ (m²·a)

E

Anne tn 59

< 2017
202
kWh/ (m²·a)

E

2019
149
kWh/ (m²·a)

C

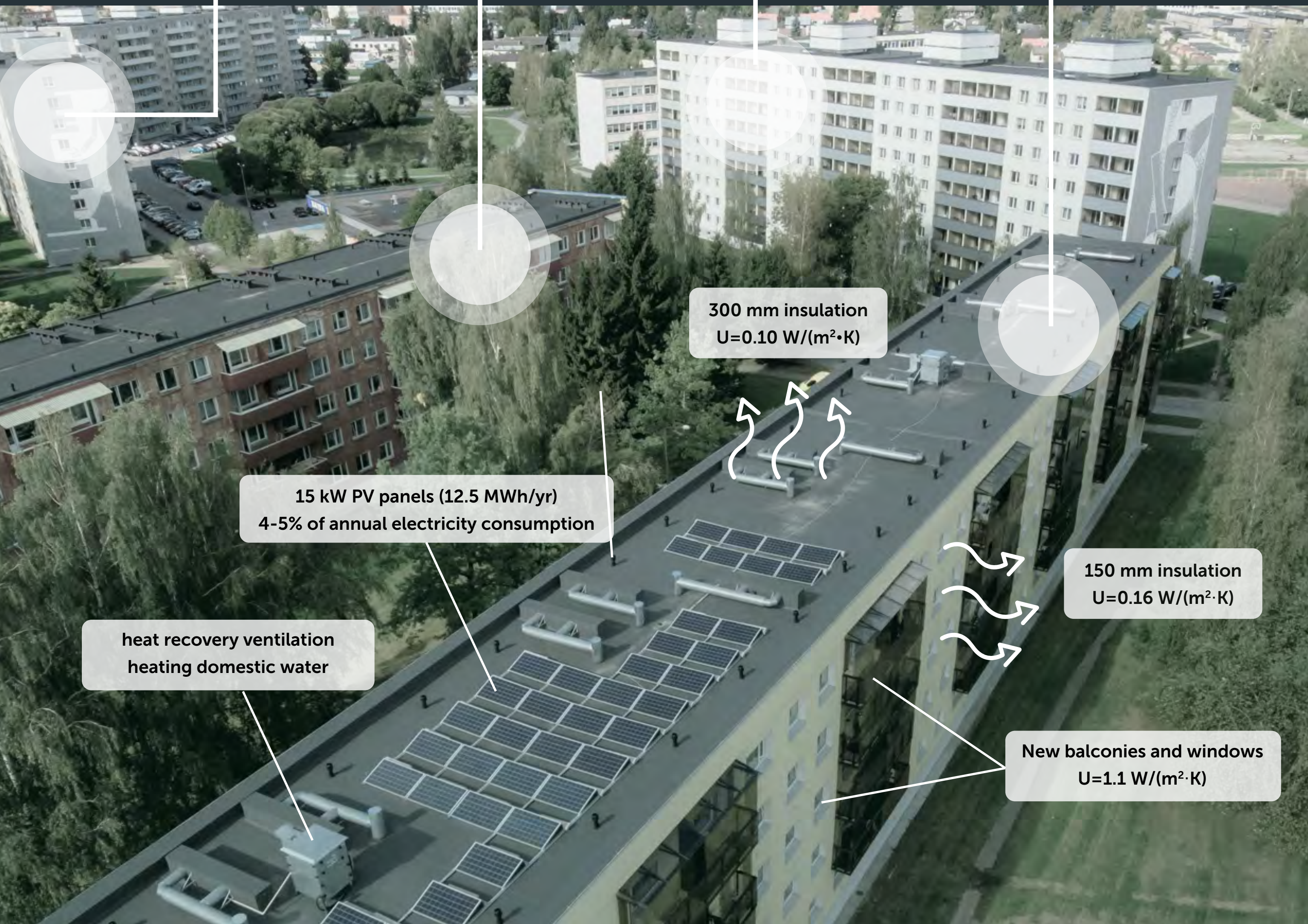
Kalda tee 12

< 2017
234
kWh/ (m²·a)

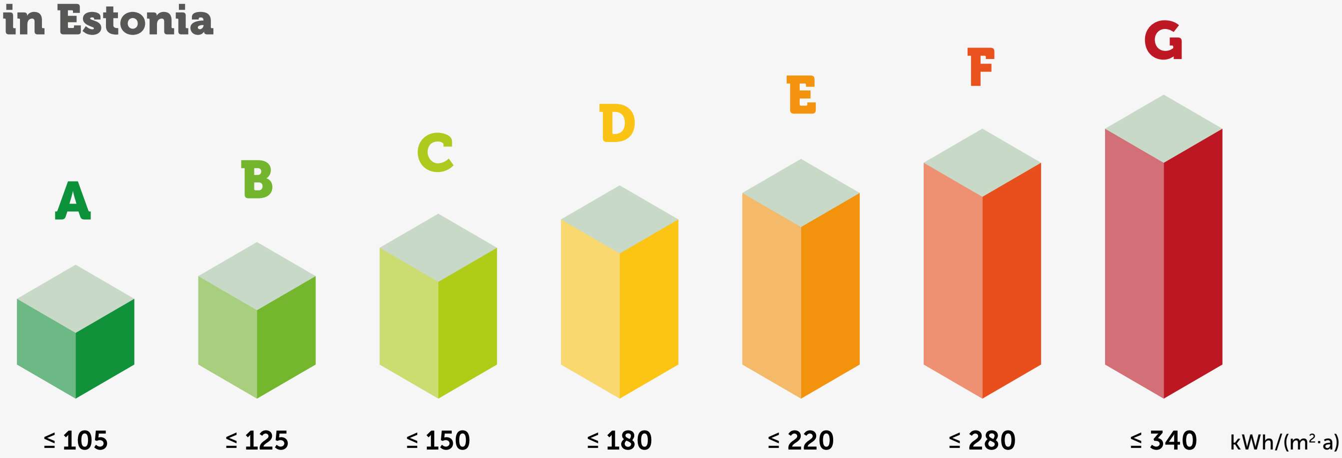
F

2019
147
kWh/ (m²·a)

C



Energy label classes of apartment buildings in Estonia



The total effect of district scale renovation in Kalda EID

13 apartment buildings

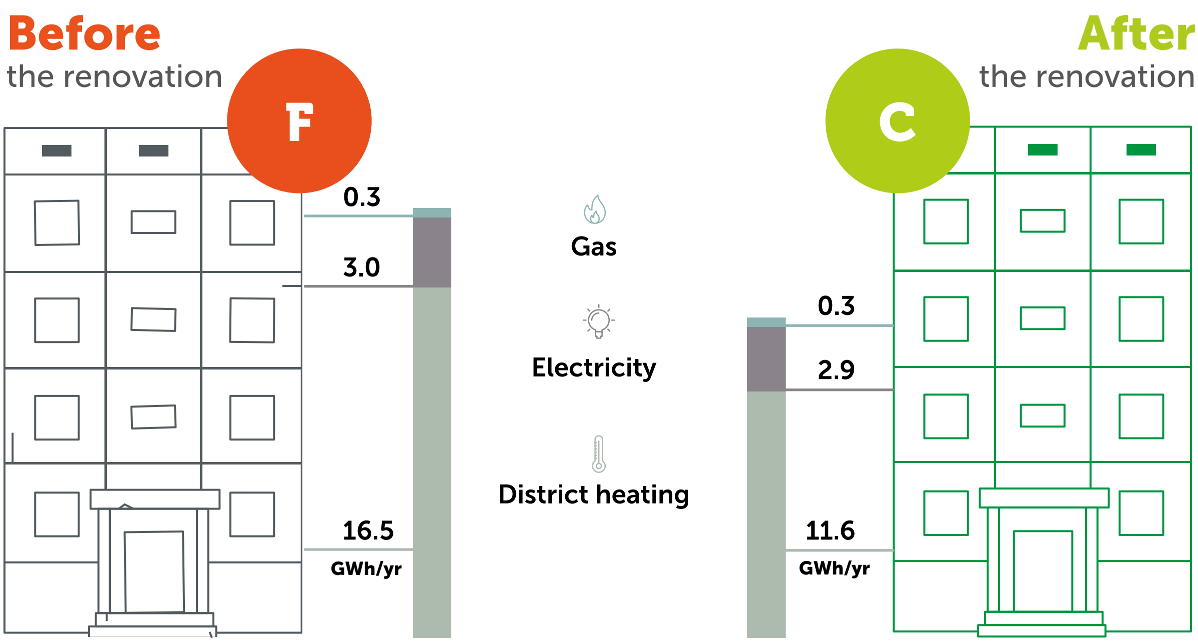
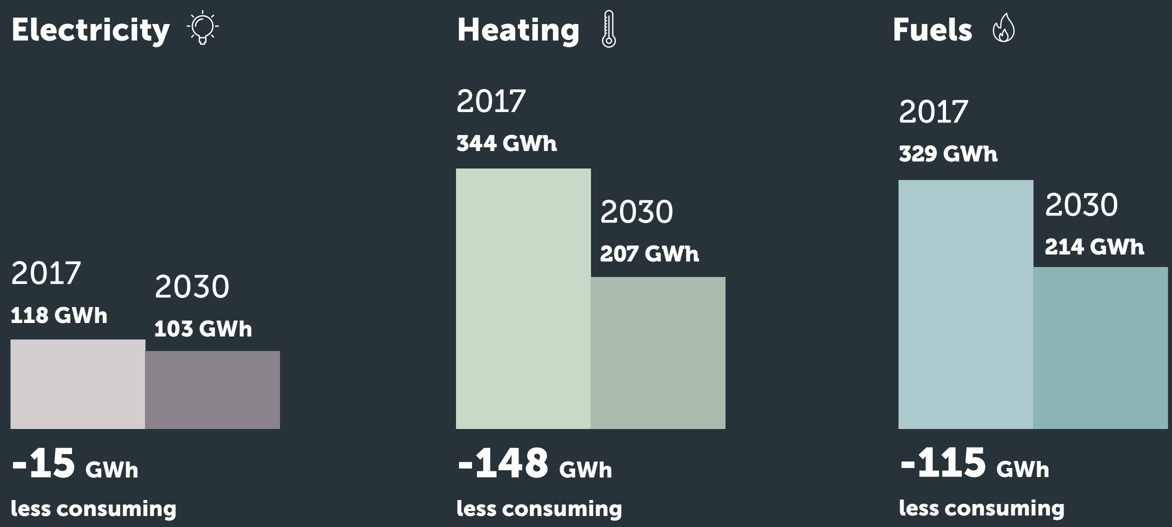


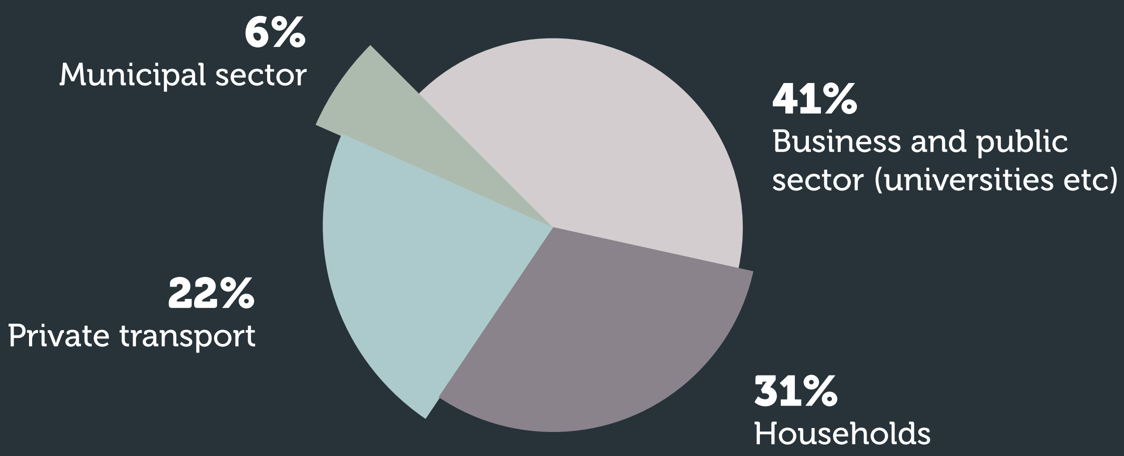
Plate 2

The Sustainable Energy and Climate Action Plan 2030 Tartu city

to be adopted in 2020



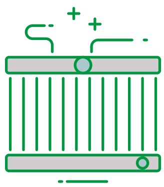
Sectoral breakdown of energy consumption in Tartu for 2017



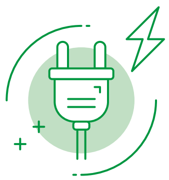
System design, features, data input-output

The system is designed to enable different ways to input data. Every user can add multiple buildings' (objects') energy data. The object can be a whole building, just one apartment in a building or detached house.

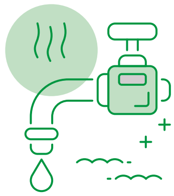
The application and its main functions are based on the calculation of the energy label in Estonia. Therefore, it is designed to have input options for three types of energy consumption:



SPACE HEATING



ELECTRICITY



HOT WATER - WATER HEATING

In addition to these energy sources, on-site photovoltaic panel electricity production and consumption data can be added to the system.

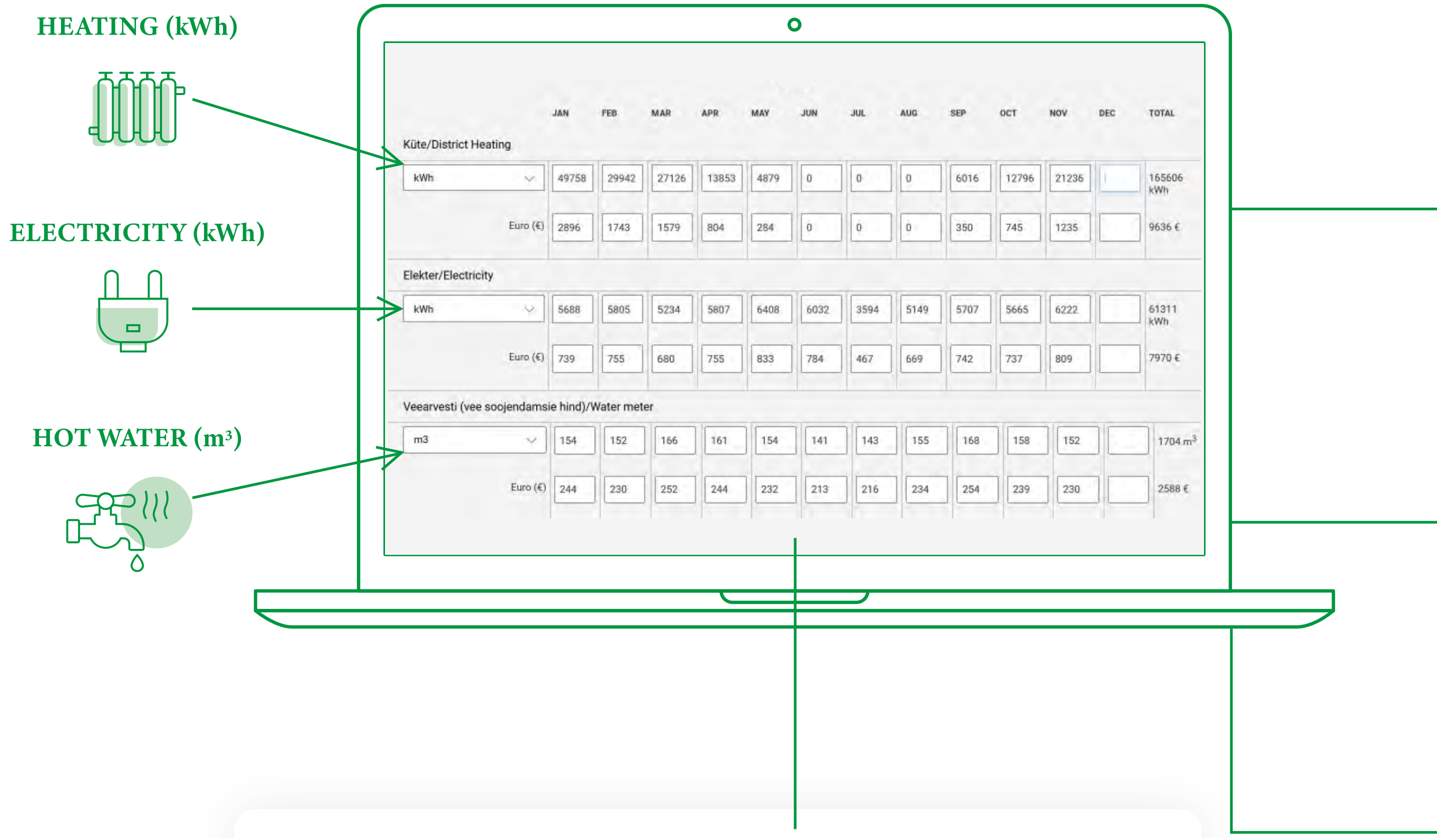
The tool is designed to allow a user to input data monthly – the energy bill data can be converted for the system. All main types of energy sources are independent from each other, except electricity. If two types of energy consumption have the same energy source, the consumption from each source must be calculated separately or additional meters must be installed.

To register electricity consumption, it is most important to input official energy meter data under electricity consumption type. Consumption measured with additional electricity meters (sub-meters) and added under space heating or water heating type will be automatically subtracted from electricity consumption type to draw computation graphs or calculate the energy label.

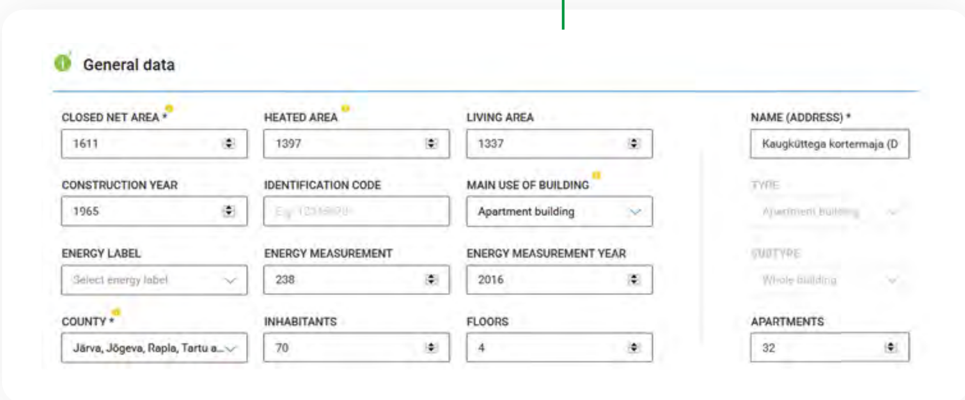
System design scheme

DATA INPUT

The data input module is connected to the dashboard.



		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Küte/District Heating	kWh	49758	29942	27126	13853	4879	0	0	0	6016	12796	21236		165606 kWh
	Euro (€)	2896	1743	1579	804	284	0	0	0	350	745	1235		9636 €
Elekter/Electricity	kWh	5688	5805	5234	5807	6408	6032	3594	5149	5707	5665	6222		61311 kWh
	Euro (€)	739	755	680	755	833	784	467	669	742	737	809		7970 €
Veearvesti (vee soojendamsie hind)/Water meter	m3	154	152	166	161	154	141	143	155	168	158	152		1704 m³
	Euro (€)	244	230	252	244	232	213	216	234	254	239	230		2588 €

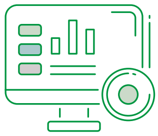


General data

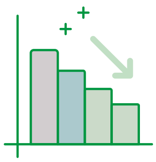
CLOSED NET AREA * 1611	HEATED AREA 1397	LIVING AREA 1337	NAME (ADDRESS) * Kaugküttega kortermaja (D
CONSTRUCTION YEAR 1965	IDENTIFICATION CODE	MAIN USE OF BUILDING Apartment building	TYPE Apartment building
ENERGY LABEL Select energy label	ENERGY MEASUREMENT 238	ENERGY MEASUREMENT YEAR 2016	SUBTYPE Whole building
COUNTY * Järva, Jõgeva, Rapla, Tartu a...	INHABITANTS 70	FLOORS 4	APARTMENTS 32

DATA OUTPUT

The output module is divided into four separate energy modules and a sharing module.



Dashboard

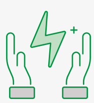


Benchmarking

Energy labelling

Functionalities and energy efficiency measures

Money saving

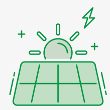


Energy saving

Renovation (A,B,C label)

Behaviour change

CO_2 reduction



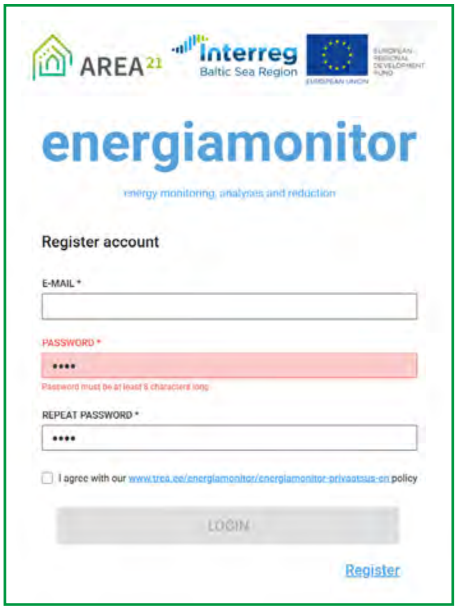
Add solar panels

Security and data privacy

The application is designed to comply with the legal acts of the European Union and Estonia while processing the personal data of users. In order to protect safety and privacy, logging in to Energiamonitor is protected with a password that must meet the given complexity requirements.

Data is stored in servers located within a member state of the European Union and protected according to best possible means and knowledge.

Users' or other persons' personal data will not be disclosed without their consent or other grounds arising from law. The data being processed originates from data the user personally discloses or allows to be disclosed (third-party databases) and information which becomes known during use of the application.



General terms and privacy policy of Energiamonitor

"...

2.3 Data processing

Data processing is based on primarily on the consent given by the User to the Service Provider to process the data disclosed by the User, data received from third databases under the User's consent, and data collected about the use of Services. When disclosing personal data while using the Service, the User grants the Service Provider permission to process all the entered data within the scope and for the purposes described in the Privacy Policy.

The objective of collecting and processing data is primarily to provide, maintain, protect, improve and develop new Services. The Service Provider will also use the data to develop and provide Users with customized content.

The Service Provider may use the data entered by the User in the web application for analysing trends and conduct surveys and make summaries for publication while granting user anonymity.

The Service Provider will ensure high quality of processed data as much as possible. The Service Provider may change the entered data in the extent required for the high-quality operation of the Service. The User is still responsible for the correctness of data they disclose.

..."

The service provider will receive user data in three ways:

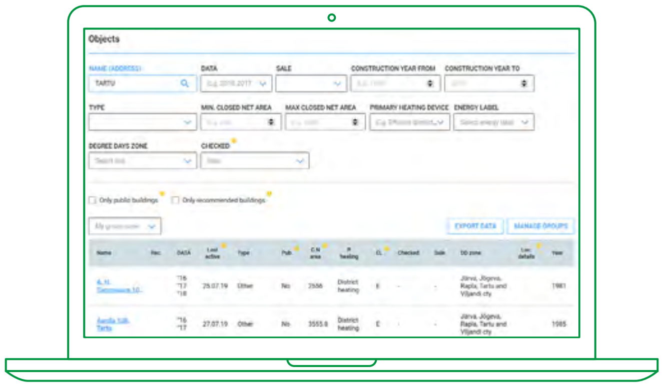
- The user submits data on their own.
- Data concerning user behavior and the use of the services is collected with the use of trusted and recognized third-party applications.
- Data received from third parties based on an inquiry made by the service provider or a cooperation partner thereof under the user's authorization.

The objective of collecting and processing data is primarily to provide, maintain, protect, improve and develop new services. Entered data can be used to analyze trends, conduct surveys and create summaries for publication while granting user anonymity.

Support

The tool is designed to be as user friendly as possible while having expert analysis functions, which requires as accurate energy data as possible. It is intended that users will learn to use the tool by individual hands-on learning, while the user interface includes tool tips and guidance and an **easily accessible helpdesk with an e-manual.**

The application has an admin module with a user management and object management section to advise and support users in data entry, energy efficiency and reconstruction issues and to validate objects for database and comparison. The admin module has a built-in function to help building owners in the middle of the renovation process with keeping track of the steps until a turnkey solution can be offered.



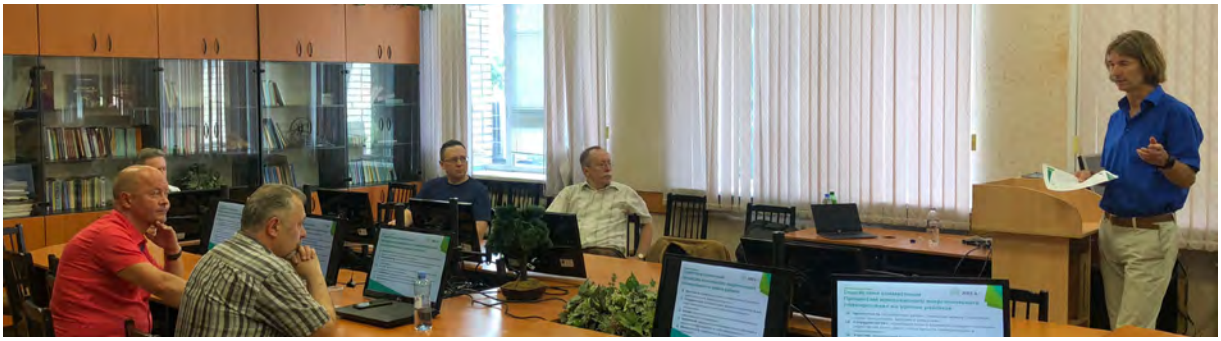
In addition, **introductory and training sessions** were organized to help users to see the functionalities of the application and to offer consultation to users about how to input data for more complicated objects. Users with more complex user stories or users who need additional consultation are assisted through telecommunication or face-to-face meetings. Training sessions and helpdesk feedback with Q&A are used as input for application improvement and further development.

Training

- **Introductory session**
- **Setting helpdesk** for ICT support
- **Group-wise and individual training:** data input, analytics, output
- **Advanced training:** verified energy reports, follow-up actions
- **Testing and end-user evaluation:** feedback, questionnaire, upgrades

Group training in Tartu on May 20, 2019; tutoring by Marten Saareoks.

Training session in Kohtla-Järve on May 23, 2019; introduction by vice mayor Vitali Borodin.



Professional workshop in St. Peterburg on June 23, 2019; tutoring by Antti Roose.

Timeline of development and testing

2018

July

Preparation of the terms of reference for the procurement of the application and procurement for the development of the ICT application

Sept.

Start of development activities: first meetings and clarification of the framework with the IT development company

Oct. 2

Launching design development environment for application views in Invision

Oct.

Abandoning of interconnection with the Estonian Building Registry and Elering's electricity consumption database

Abandoning person-based user authentication to simplify user creation

Nov.

Decision to start calculating renovation results based on energy label calculating methodology

2014—2019

The growth of apartment building renovations and the need to raise awareness and assess energy use

2015—2017

AREA 21 project proposal, incl. idea of ICT application development

2013

E-jälg: an environment for storing and basic visualizing energy consumption data of municipal buildings

2010

Need for monitoring and storing energy data of Tartu City Government's buildings

Jan. 9
Launching test environment of application on the developer's server

Febr. 25
Application running in TREA's server

Apr.
Adding web analytics software to application

Deciding to use Energiamonitor branding instead of initial e-monitor

May 19
Launching Energiamonitor application to the general public

2019

July—Sept.
Development of a stand-alone Polish version and uploading it to the Polish server

Nov.—Dec.
Collecting user's feedback and improving the user-friendliness of the application

2020
Wider promotion of the application and increasing the number of users

1. Professional testing

- scope and develop
- internal testing
- heavy mods

2. Automated analytics of usage

- develop
- internal and external testing
- medium / heavy mods

3. End-user satisfaction

- end-user feedback (testing)
- support
- minor mods

Testing

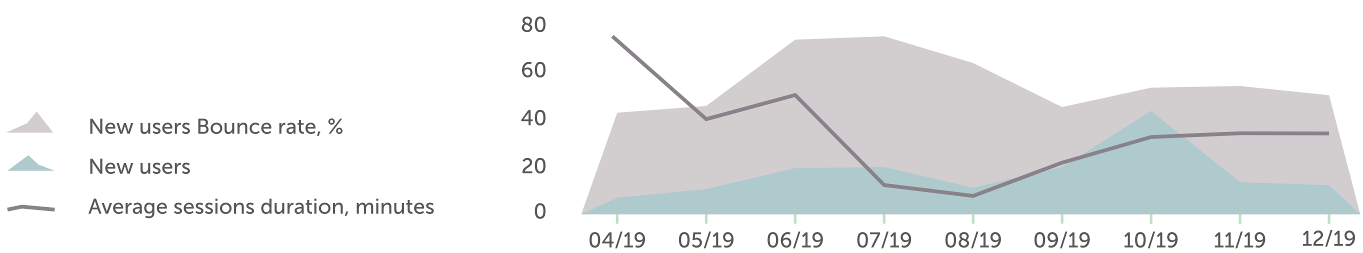
Three different types of inputs have been used for testing and user feedback:

1 Professional testing

- List of feedback with solutions. Q&A, interviews with users who tested and used application.
- Initial scoping and developing, major changes were included.
- Professional testing phase turned out to be the most constructive for feedback and development.

2 Automated analytics of usage

- Using automated tools for collecting user experience data and statistics – Hotjar and Google Analytics.
- People from outside development workgroup circle started to use and test application. Also automated tools were added to system to register base data of user experience and site statistics. A duplicate test site was introduced for initial testing of app modifications to launch it for public only after successful results in test environment.
- Automated testing gives overview of general user statistics for at least volume of traffic on the site Energiamonitor has had so far.



3

End-user satisfaction

- Online feedback questionnaire aimed at exploring the end-user satisfaction of the tool and service.
- This phase mainly involves the day-to-day management of the app and its users and their concerns.
- Questionnaire and continuous user feedback adds another layer of input to improve the application.

Problems and issues

In the course of the development process, all observations and problems have been recorded and tables have been drawn up to list all needed modifications and to monitor their implementation.

- **Data Input:** simplicity and clarity. In initial object registration, seemingly too much information is asked, even if all fields are not required to be filled in. The water heating component input logic is hard to understand and once understood it is complicated to provide the data.
  Recommendation: Automatic (database-database) energy data input is needed.
- **Performance issues**: In application navigation, graph and tables design, accuracy and clearness of the results.
- **Texts and translations**: Accuracy and clearness in the text and layout of the translations.

Recommendations and conclusions

The following need to be agreed in the development process:

These dilemmas have created a discussion throughout the development and testing period. It is important to take a firm stance on scope, even if it changes over time. Suggestions for developing the applications are as follows.

1. Consistently have a clear vision of the scope of the application and which type of user it is for. Where possible, carry out a market analysis.

2. Make the most thought-out project assignment and procurement by making a list of the functional objectives maintained in the project assignment and procurement.

3. Agree on a sufficiently precise timetable, check its execution and immediately add a justification or note and a new deadline if any deficiencies occur.

4. Build a team with insiders who are able verify within the application's core whether important functions are working as soon as they get first access to the live application (test phase 1). Start collecting and listing all concerns.

5. Broader piloting of the project (test phase 2). General application bugs should be resolved. In this phase, a broader range of users should help identify more detailed errors and problems, and additional specific cases. Collect and list all concerns and start collecting user activity feedback with automated applications (e.g. Google Analytics, Hotjar, Inspectlet, etc.)

6. Make sure that all pending concerns are resolved (rejected or implemented) before full-scale launch of the application. Be prepared to respond to end-user problems and questions quickly and accurately.

7. It is useful to have a duplicate pre-live version of the application to test modifications inside the internal group of people before updating the main application.

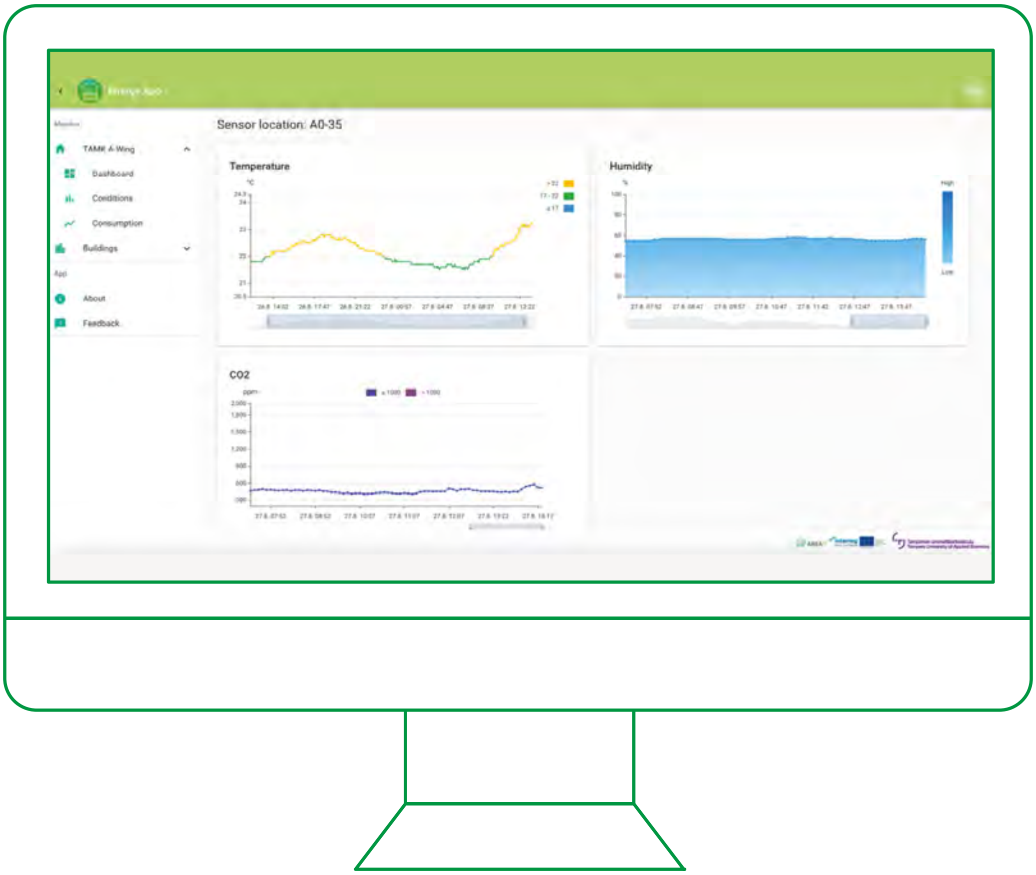
3.2

Energy Monitoring Tool

Tampere, Finland

area21.tamk.cloud »

Kari Kallioharju
Esa Parkkila
Pekka Pöyry
Ari Rantala

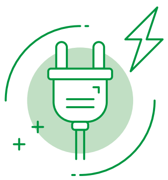


area21.tamk.cloud

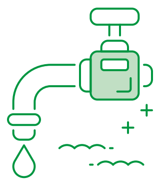
Introduction

The energy monitoring tool, also referred to as “Energy application from TAMK” (ENAP), is an application for monitoring and analysing real time electricity and domestic water consumption and indoor conditions in apartments and single-family houses.

The user of tool can monitor



Real time electricity

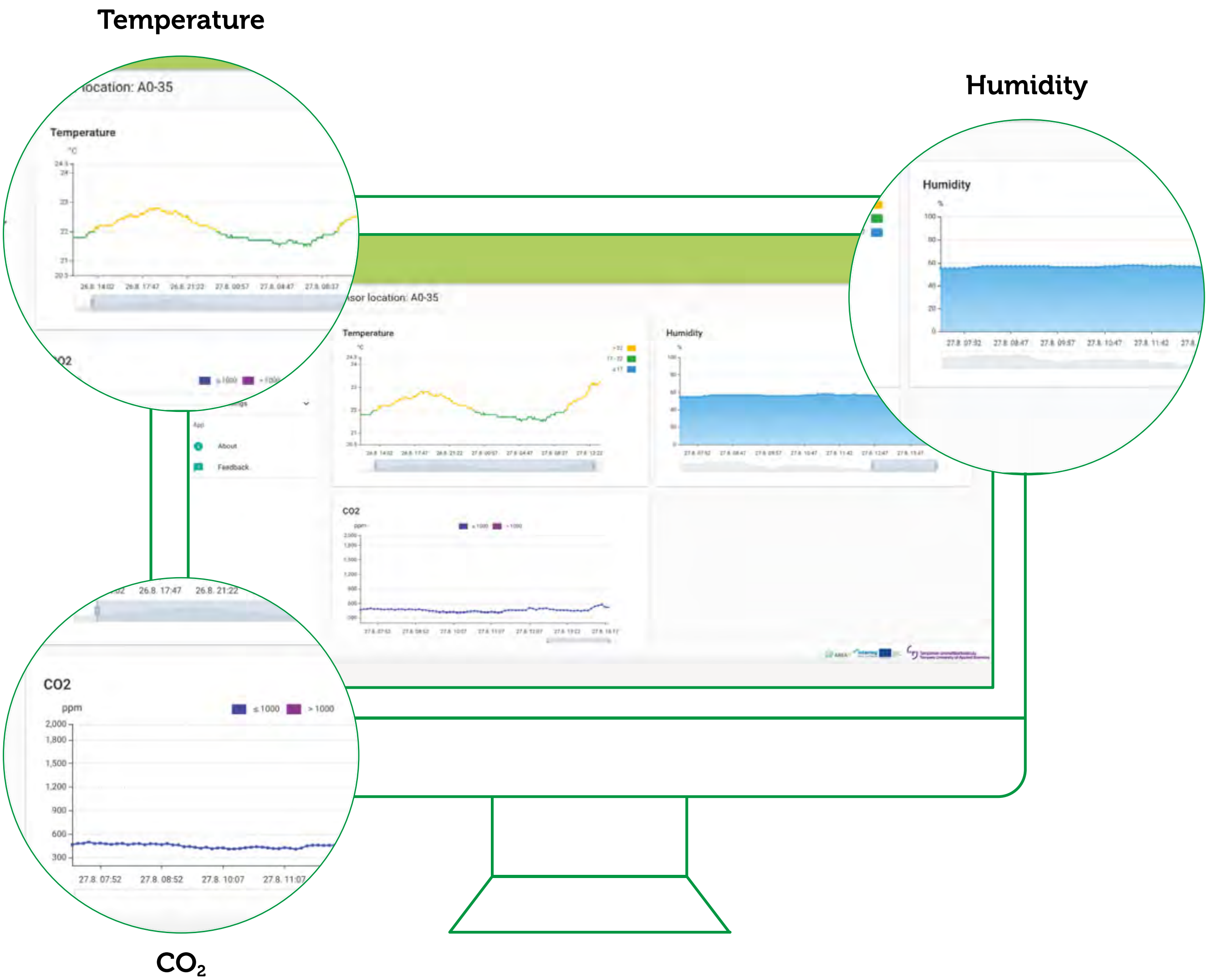


Domestic water consumption

Indoor conditions

It was developed in Tampere University of Applied Sciences (TAMK) between ICT Engineering, Software Engineering, Building Services Engineering and Business Information Systems in 2018-2019. The tool collects real time data of apartment energy and water consumption and indoor conditions with sensors, energy meters and an optional building automation system and visualizes the apartment’s real time data for user in trend line graphs and total consumption calculations (Figure 6).

Figure 6: Screenshot of energy monitoring tool presenting indoor conditions of one room.



The tool's user interface is web based, and every user has a personal account to monitor their apartment's data. The main goal of the tool is to raise individual knowledge about energy consumption and foster behavioral change in users. The user interface is currently available only in English.

Energy Improvement District

Härmälä, Tampere

Härmälä EID (8,000 inhabitants) is a district-scale model of the whole city of Tampere (230,000 inhabitants). Härmälä is situated three kilometers south of the city center. It comprises areas with newly constructed and older multi-family blocks, areas with older detached houses as well as industrial uses. Piloting of energy monitoring tool Pirkka 7 is (also) located in Härmälä.

Pirkka 7

Nuolialantie 48, 33900 Tampere

Owner: POAS, Pirkan Opiskelija-asunnot Oy

117 apartments in total area 5007 m^2

Construction year: 2014

Pirkan Opiskelija-asunnot, POAS for short, is a limited nonprofit company owned by the City of Tampere. At the moment, the company owns over 30 housing complexes around the city. The flats are rented to students at the schools in Tampere and the Pirkanmaa region, as well as to working people under 30 years of age. POAS offers flats near the colleges and universities around Tampere, close to good traffic connections.

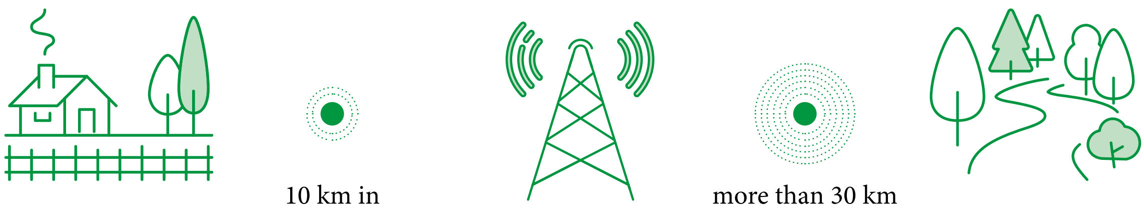
Residents (tenants) in Pirkka 7 are students and young people.

System design, features, data input-output

The energy-monitoring tool is mainly based on wireless LoRa sensors, meters and networks, and data from the sensors is transferred to TAMK servers located on the university campus. In the current system, domestic water data is collected via a building automation system by using FTP protocol. The conceptual system architecture is described in Figure 7.

Wireless LoRa (Long Range) technology and LoRaWAN are used in many Internet of Things (IoT) sensor networks worldwide. The LoRa network is particularly suitable for transmitting small amounts of data. The number of sensors utilizing LoRa technology is growing rapidly. This increases the interest of technology in IoT solutions. LoRa uses a license-free ISM frequency band.

LoRa enables long-range transmissions with low power consumption

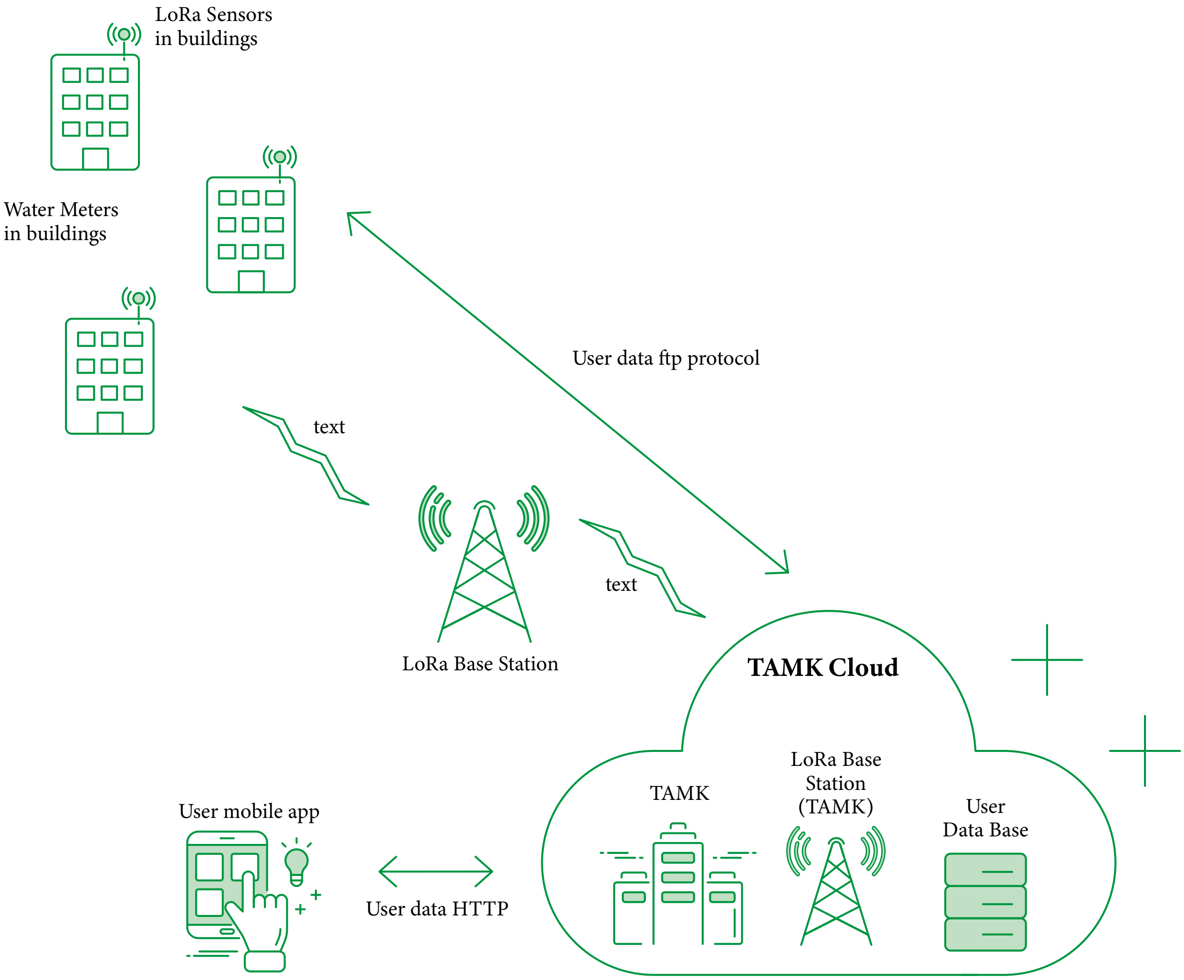


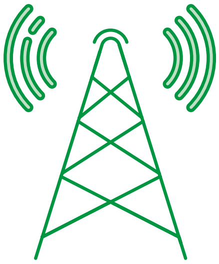
10 km in sub-urban area

more than 30 km in rural areas

This project uses a European frequency band of **868 MHz**.

Figure 7: Architecture of energy monitoring tool.



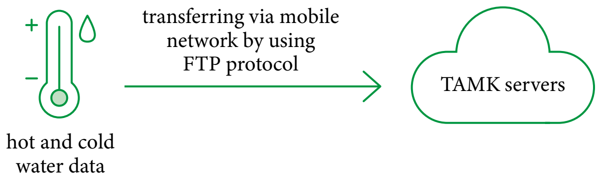


The LoRaWAN specification is a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated 'things' to the internet in regional, national or global networks. It targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services.

Two indoor condition sensors are installed in all pilot apartments, specifically in the living room and in the bathroom. LoRa electricity meters are based on an optical reader and were installed in the basement of apartment houses where the power utility company's electricity meters were also located. Figure 8 shows the indoor condition sensor and the electricity meter used in the project.

In piloting property, every apartment's domestic hot and cold water data was collected via the building automation system.

Hot and cold water data was transferred in TAMK servers via mobile network by using FTP protocol.



All data in the piloting period was collected in ten- minute intervals to achieve a reasonable battery life. LoRa sensors and meters use batteries to measure and send data.

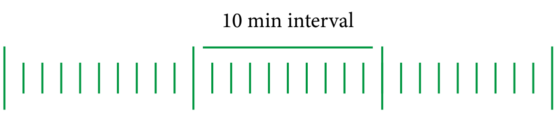


Figure 8: Monitoring hardware in the AREA 21 project.

A) LoRa indoor condition sensor

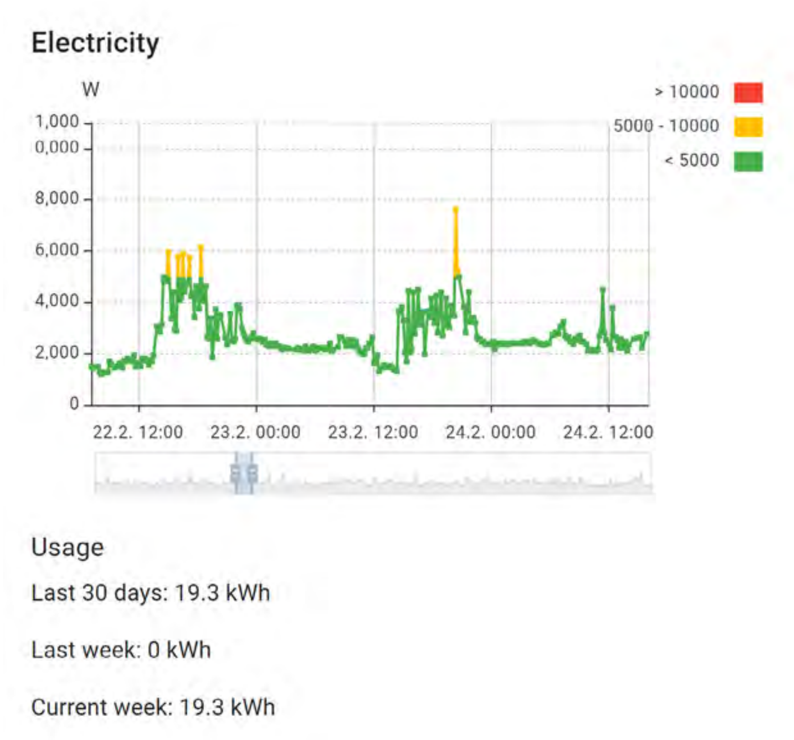
B) LoRa electricity meters

The tool collects the data in TAMK servers and the user can monitor their apartment's data via a web-based tool interface. Every apartment's data is private, and the tool login requires user accounts and passwords to be set up before it can monitor the apartment's data. The tool currently monitors some public areas and collects electricity data from the shared spaces of the building, and then every user has their own private data that presents the apartment's indoor conditions (temperature, humidity and CO_2 [only living room]), the domestic hot- and cold-water consumption and the electricity consumption. The tool visualizes real-time data in different charts, for example, line and bar charts. As an instructional feature, the charts change color depending on measurement results (e.g. rising electricity consumption changes trend line color from green via yellow to red). Trend lines are presented in Figure 9.

Figure 9: Trend line charts on electricity consumption (left) and temperature (right).

Figure 10: Electricity consumption during 22.-24.02.2020.

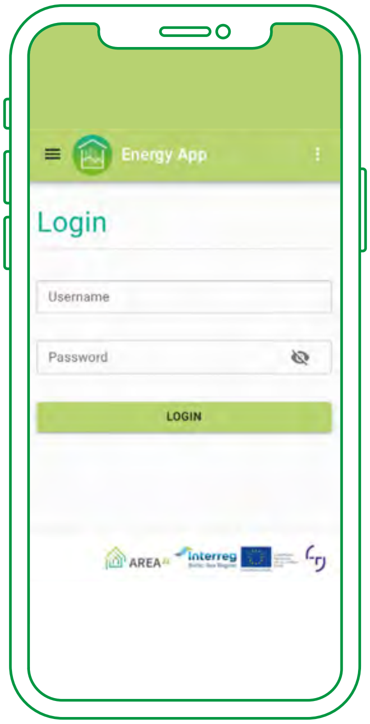
Sensor location: Power room



Besides charts, the application also calculates domestic water and electricity consumption in weekly intervals and from the last 30-day monitoring period (Figure 10).

A feedback channel is available on the tool for questions related to energy consumption, indoor conditions and application specific questions. There are also numerical values and extra information about the recommended value ranges for the user in the tool subsections. For example: "Recommended indoor temperature is 20-22 degrees and typical humidity between 20% and 40%".

Security and data privacy



The application is designed to comply with the legal acts of the European Union and Finland. In order to protect safety and privacy, ENAP login is password protected. Every user has also made an individual agreement with Tampere University of Applied Sciences regarding data collecting, analysing and handling.

Data is stored in servers located on the TAMK campus and protected according to the best possible means and knowledge.

Support and training

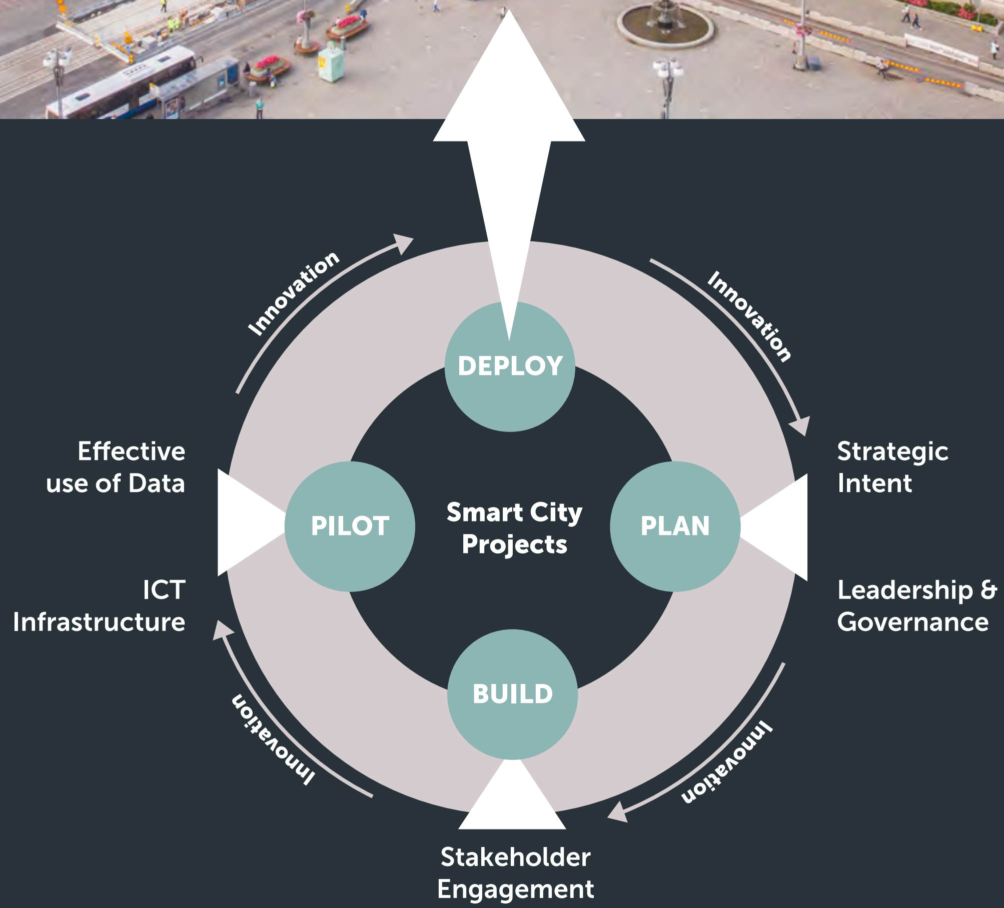
The tool is designed to be as user friendly as possible. It is intended that users will learn to use the tool by individual hands-on learning. Besides that, the user interface includes some guidance, a feedback channel, and the contact details of the persons responsible for the tool. In addition, introductory and training sessions were organized to help the users to see the functionalities of the application and to improve their energy efficiency in everyday life.

Training sessions and the helpdesk feedback with Q&A is used as input for application improvement and further development.

Smart Tampere

Strategic development programme of the City (2017-2021)

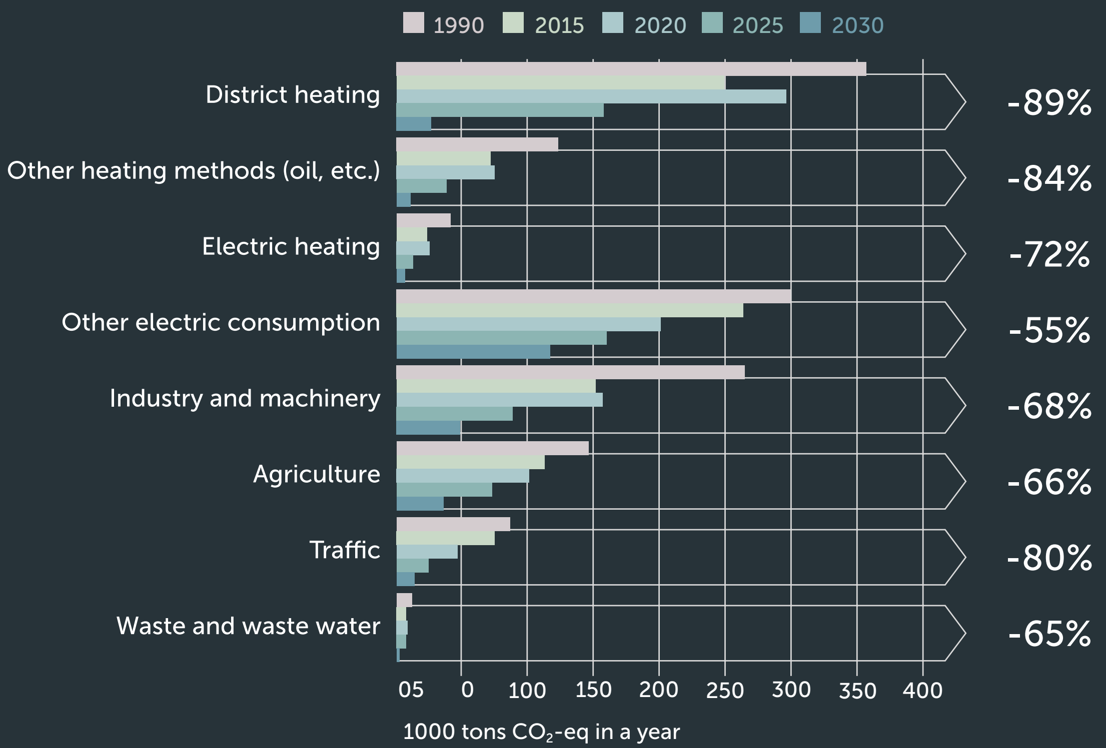
Sustainable Tampere 2030	Digitalization Programme	Ecosystem Programme
"Carbon neutral Tampere 2030"	"Digital services 2025"	"Platforms and ecosystems"
TAMPERE	TAMPERE	BUSINESS TAMPERE



Nick Cotton, 2019. The Smart City, Cookbook, A Recipe for Successful Smart City Programs, City of Tampere

Sustainable Tampere 2030

Tampere aims to be carbon neutral by 2030



ICT Projects of Smart Tampere

- **The EU–GUGLE project**
  Housing companies, nearly zero energy renovations, innovative technologies
- **The STARDUST project**
  ICT solutions in new buildings, solar energy solutions and energy communities
- **City IoT project**
  The future operator independent data integration platform (City IoT) project invites companies to join the specification of the open data integration platform for cities and to develop new business models enabled by the platform
- **Energy Wise Cities project**
  City owned buildings, ICT solutions for energy, indoor air quality and space usage rates
- **CARE project**
  Building managers' training in energy issues, housing company services

Plate 7

Timeline of development and testing

2018

Phase 0

Defining the tool

Sept. 2017

Phase 1

Pre development

Apr.

Phase 2

On-site installations

Oct.

Database and basic user interface bug fixings.

The first online survey

It included sections regarding preferred features of tool.

Energy Monitoring Tool (ENAP) development and testing is divided in **three different sections:**

- User experiences and behavioural changes
- Testing and development of software
- Testing and development of technical system

2019

Phase 3
Alpha release
Febr.

Phase 4
Beta release
Apr.

Phase 5
Tool launch
Aug.

Phase 6
Analysis and reporting
Nov.

Physical installations, signal strength, reliability, and battery consumption tests.

Development and software bug fixings.

Feedback was collected in joint meetings, face-to-face, via email and tool feedback channel.

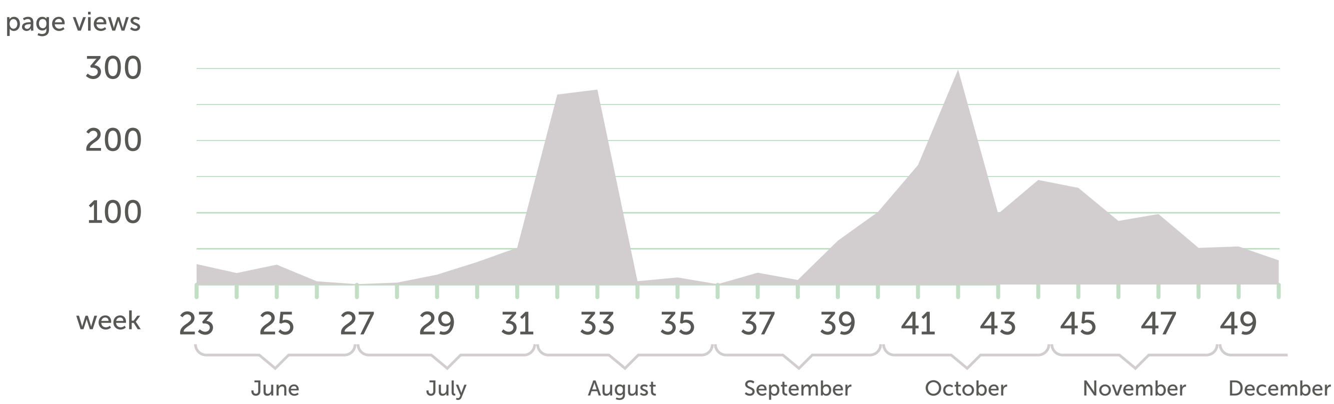
The second online survey

It included questions regarding end-user satisfaction from different points of view (sensor installations, user interface usability and features, support, effect of tool on energy consumption behaviour, etc.)

Google Analytics statistics

Google Analytics was launched in early June 2019, in the middle of beta testing, phase 4. The overview of the user activity is shown in the Figure 11.

Figure 11: Weekly user activity of energy monitoring tool between June - December 2019.



It can be clearly seen that there was significant activity on the webpage after the tool's launch in late July, and then interest steadily rose during the official testing period from late September and was affected by maintenance visits. The survey was sent to users, reminding them about the tool. In addition, other users found the tool via the AREA21-project webpage, so not all users were tenants living in a pilot project property.

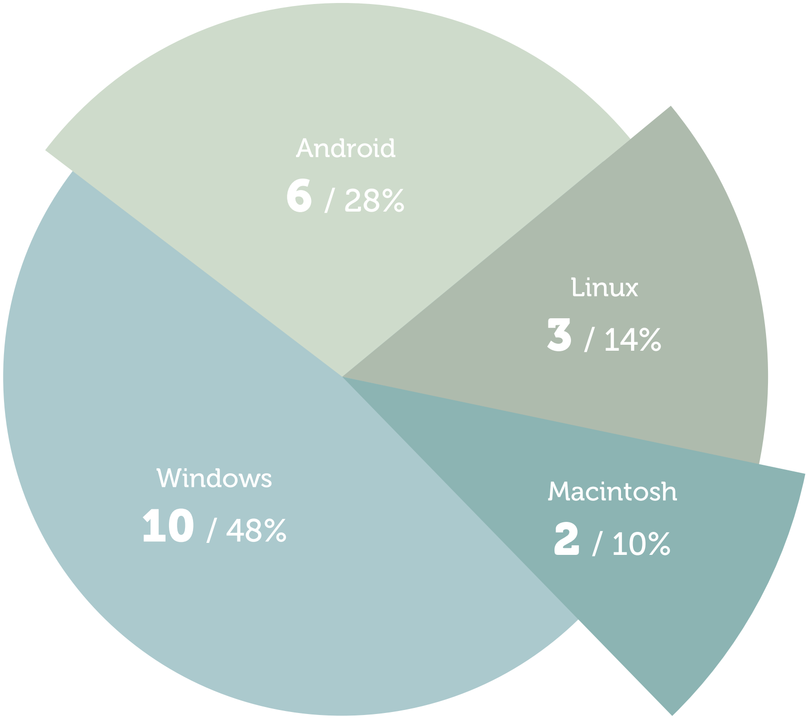
Figure 12: New and returning visitors of energy monitoring tool between June - December 2019.

During the monitoring period, there were 81 visitors to the webpage, 32% of them used the app again.

Figure 13: Geographic locations of the visitors.

The visitors are from different countries. Most of them are from Finland (about 73%), Canada and Estonia (about 5% both), then Poland, Germany, Denmark, Russia, the Netherlands and Sweden.

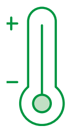
Figure 14: Operation systems of application users.



In Tampere area (Finland), 20 out of 81 visitors returned. Most of them are inhabitants of apartments. In Figure 14, the operation systems of the users is presented. Android is the only mobile OS here.

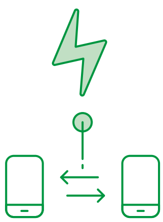
User experience and motivation

End-user satisfaction was collected and analyzed during the whole piloting period. Feedback was collected in joint meetings, face-to-face and via email and the tool feedback channel. At the end of piloting, there was an online survey delivered for users regarding the tool and end-user satisfaction. The project team also monitored tool use rates with Google Analytics from the time of the beta release, when all volunteer users were involved in testing. The app was considered quite clear by trial users. The application has been as easy to use in a computer browser as in a mobile browser, according to the feedback from the questionnaire.

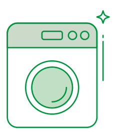


Users were most interested to **in monitoring the temperature of the apartment.**

Energy monitoring turned out to be a relatively new idea. Users did not have any idea what“normal” energy use was for them.



Users would have liked to see **additional features in the tool,** e.g. energy comparison features between neighbours and other users; gamificational and instructional features.



Users admitted that **more accurate consumption information** for different appliances (e.g. washing machine, dishwasher) would be needed for changing their own habits.

Recommendations and conclusions

Residents' commitment to monitoring energy consumption

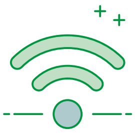
The pilot population was mainly university students. Whether the mere habits of this pilot group in monitoring energy consumption can be considered a general trend remains to be considered. The ability to utilize modern IT systems and applications supports the target group selection. However, IT systems and ease of use alone did not seem to encourage residents to monitor energy consumption. According to the survey, the temperature of the apartment was the most closely traced information. Looking at temperature data from an application, instead of a thermometer on the wall, might be a signal of interest in energy monitoring.

1. **According to the survey, no one wanted to comment on whether they would be prepared to pay for such a service.** It should be considered when developing commercial systems.

2. **This pilot test did not include any single-family homes where data tracking could potentially address the change of habits more clearly.** The different age groups and urban districts should be considered in further pilot tests.

Features of sensors

Advantages



Easy scaling and modification of physical installations. System size is basically unlimited.

The sensors can be easily installed and position can be changed according to the situation.

The wireless solution is the only one that can be implemented economically on a per-apartment basis in existing building.

Updating the system and interface does not require on-site visits.

Housing companies can use data for building management, if data permission is admitted by users.

Mobile user interface is always available, so it allows remote monitoring and increases safety in case of failures.

Disadvantages

The signal range, coverage, from the sensor to the base station can be a challenge. Typically, electricity meters are located on the ground floor or basement, which causes problems with the damping caused by the walls. This was also noted in the pilot site.

Wireless sensors need a battery to function. Battery replacement should be considered well in advance.
The need for battery replacement at the pilot property surprised the project team. The exchange interval is denser than initially thought – in a worst case scenario batteries only lasted for a few months because of signal power consumption.

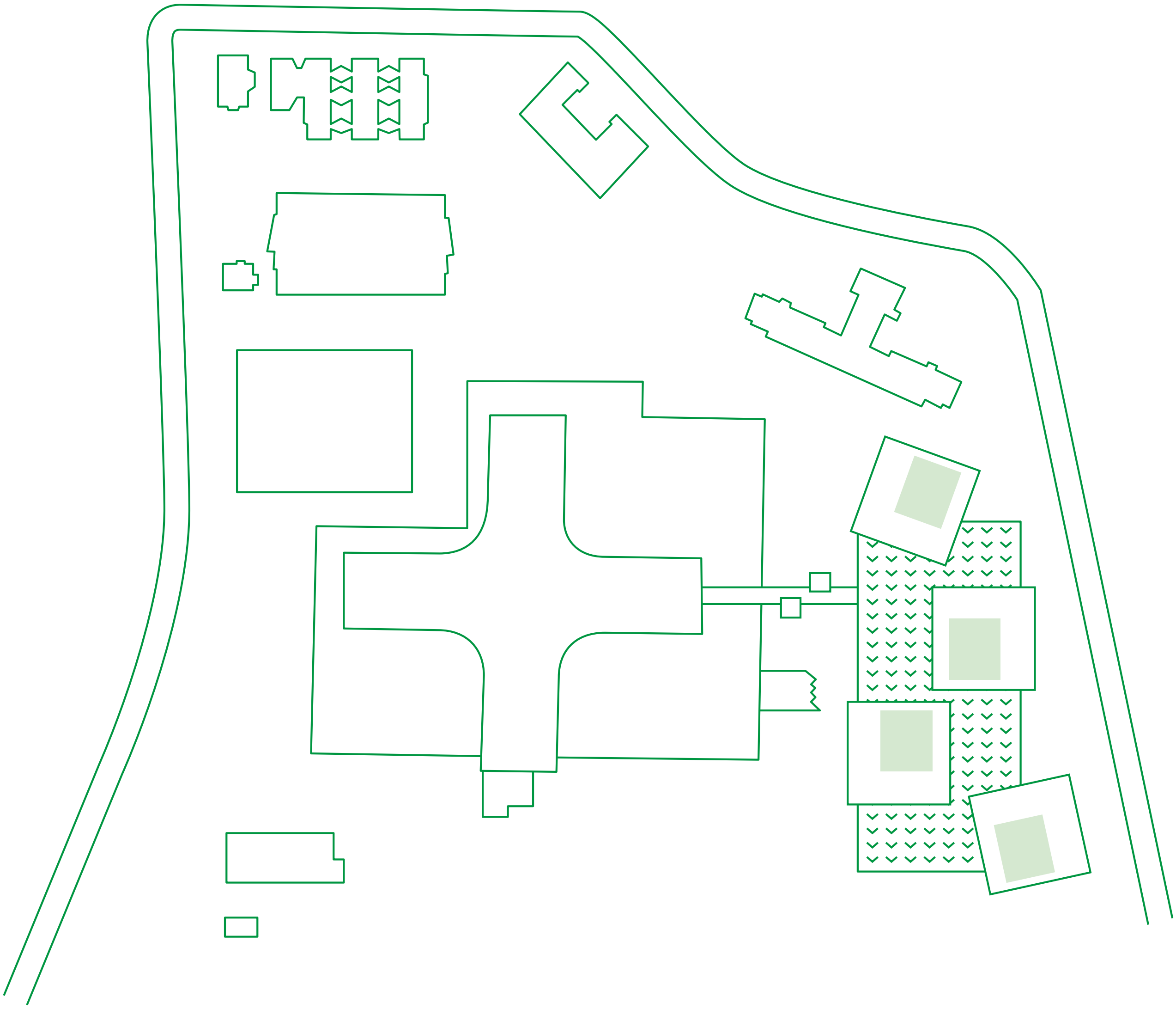
Optical pulse meters used for electricity monitoring were configured regarding electricity meter labelling (1000 pulses / kWh) but after a while project team noticed that the pulse rate was different (100 pulse / kwh). It was not a predictable issue and very difficult to avoid.

3.3

Energy Improvement Circle Tool

Helsingborg, Sweden

Henrik Gadd



Helsingborg Hospital Area

Energy efficient hospital area – thinking economy, environment and society together

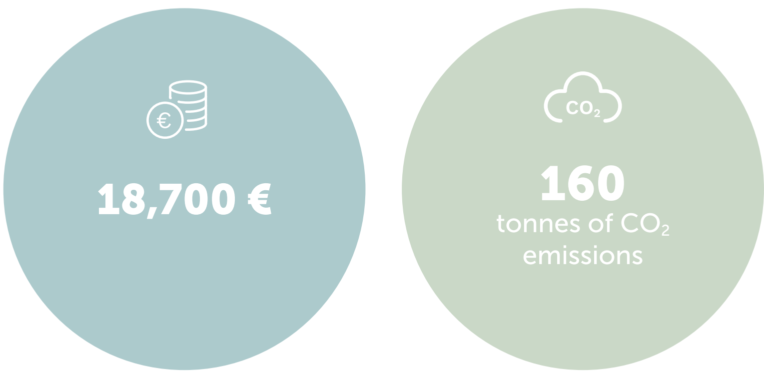
A demand-response tool for identifying and quantifying smart energy solutions for reduced cost and climate footprint.

Developed by Region Skåne and Öresundskraft

The energy sector is undergoing a transformation from fossil to renewable energy supply. In traditional energy systems, the energy supply adapts to demand, and the focus of energy efficiency matters has been on saving energy. The future energy system, based on renewable and reused energy, must focus more on saving electricity as well as heat power. As a result, the system border of energy production, distribution and thereby also optimisation must include the energy end users, i.e. the customers.

The Energy Improvement Circle Tool is a method developed to support electricity and heat power optimisation from both an economical and a greenhouse gas emissions point of view. A case study has been performed on the Helsingborg Hospital Area, which indicates that the total annual savings potential is €18,700 and 160 tonnes of CO_2 emissions. This is an executive summary of the full report of the Energy Improvement Circle Tool, which is available at https://area21-project.eu/ict-tools/.

Total annual savings potential in Helsingborg Hospital Area



Introduction

In traditional energy systems, energy supply adapts to demand. If energy use is increased, the production units should increase supply. But this way of supplying energy has an inbuilt inefficiency. Energy producers must always have an available free capacity that can be used in the upcoming hours since the energy demand for the future cannot be 100% predicted. The classic way to solve this problem is to build energy storage centers, but the development of ICT tools has, in recent decades, enabled the possibility to involve energy users in energy optimisation. This is often referred to as a demand-response solution.

Energy efficiency matters should not only focus on saving energy, but also on saving power. Energy produced in power plants which addresses peak demands for both electricity and heat are often not only expensive but also produced with fossil fuels; that is, there are both economic and environmental reasons to decrease peaks in energy supply. Many renewable and recycled energy sources are characterised by low energy cost but a simultaneously high cost for power, for example, wind power, solar power, hydropower and waste incineration, which all have very low or even negative marginal cost. It is almost only the fixed costs, that is, power, which is expensive.

When saving energy, it is mainly a matter of an investment in insulation and energy-efficient equipment that result in less energy use. Saving power is a matter of when to use energy or not. Saving power does not necessary involve saving energy; it can simply be moving the energy use in time. However, this process is complex because it then must involve not only your own energy use but also energy generation.

The Energy Improvement Circle Tool (EICT) is a method developed to analyse the potential savings for heat and electricity peak power reduction on an energy improvement district (EID) level. The method is visualised in Power BI, standard Microsoft software, but the method is not dependent on any specific visualisation software. To take action, it is necessary to identify where energy is used during the hour or hours that are expensive and cause large greenhouse emissions. The EICT method supports drilling these analyses from an EID level down to a single piece of equipment depending on what measurements are available. The method is described by a case study where the object of the study is the Helsingborg Hospital Area, the EID of project partners Region Skåne and Öresundskraft in the AREA 21 project.

General idea of the EICT method

Data on the EID level for energy use is used with day-ahead data regarding energy cost and CO_2eq (carbon dioxide equivalents) emissions on an hourly basis. The general idea is to reduce energy use at times when price and/or CO_2eq emissions are higher than a certain limit. When the hour for over-limit cost/emission is identified, depending on what metering is available, the option to explore the energy use in each building, a part of a building or even an individual piece of equipment will be available.

By introducing a limit for a maximum price and/or maximum CO_2eq emissions and setting up an alarm that is trigged when the price/emissions reach a certain level the next day, it is possible to reduce the cost and/or CO_2eq emissions of the EID area of interest.

Working steps

Work with the Energy Improvement Circle Tool can be divided into 5 steps:

1. Analyse the potential power savings and CO_2 reduction.
2. Identify possible electricity equipment able to be switched off on demand.
3. Identify buildings that can reduce heat demand.
4. Set up Application Programming Interfaces for price and CO_2-emissions on electricity forecast data and decide alarm levels. Application Programming Interfaces (API: s) serve as an interface for data exchange.
5. Set up an agreement with the district heating supplier for demand-side management.

The Power BI model built for the Helsingborg Hospital Area supports step 1, 2 and partly step 3. For step 4, there are Application Programming Interfaces available; however, local administrations must be developed to handle alarms. Step 5 should be solved by local negotiations between the heat supplier and heat user.

The Helsingborg Hospital Area

To illustrate how to work with the Energy Improvement Circle Tool in practice, it has been applied to the Helsingborg Hospital Area based on historical data from the year 2018.

The Helsingborg Hospital Area consists of six large and two small buildings. One of the larger buildings is a carpark (see Figure 16 Parkeringshus), which does not use any heat and only a small amount of electricity. The Teknikbyggnad and By 23 are under construction and not yet in operation and therefore excluded from the case study.

The energy use for each building in the Helsingborg Hospital Area, electricity and heat, can be found in Figure 15 below. Notable is that approximately 90% of the energy, electricity and district heating is used in the main building, By02.

Figure 15: Heated area, use of electricity and heat energy for the buildings in Helsingborg hospital area 2018 in MWh.

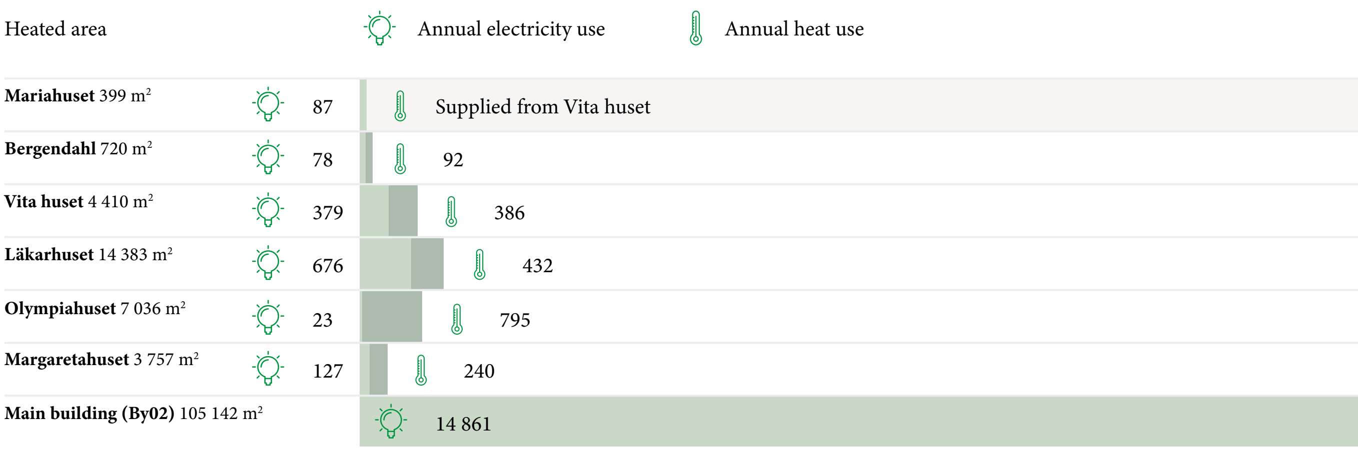
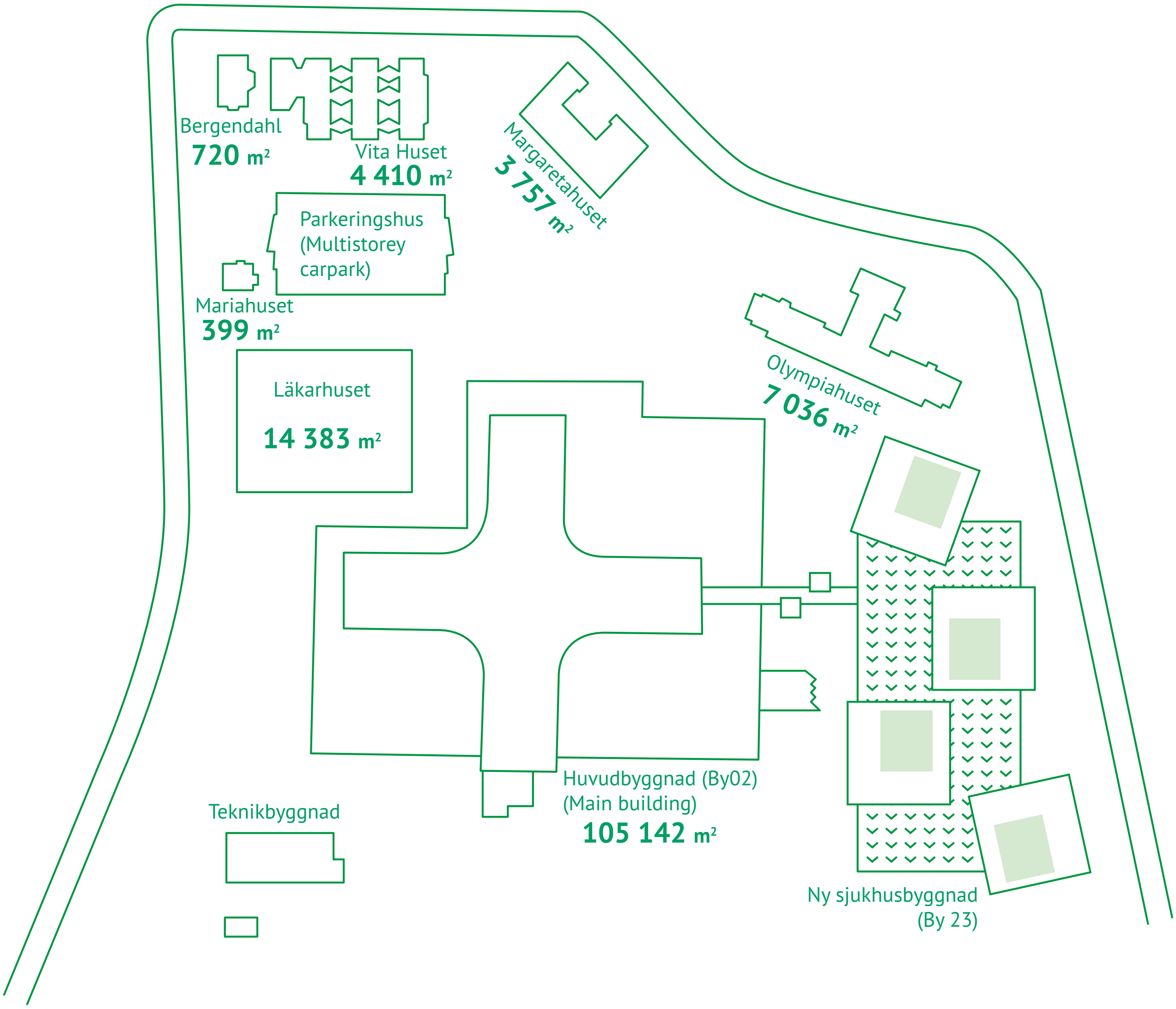


Figure 16: Map of Helsingborg Hospital with named buildings.



15 200

Limitations

The energy study includes electricity use and district heating use. There is also district cooling connected to the main building, but it is not representative and the method that is presented in this report for district heating can be applied to district cooling. The evaluation has been performed for the year 2018.

Data

Öresundskraft measures the supplied electricity and heat. Electricity is measured with one point for the whole EID, and the total use of electricity was 16 GWh during 2018. District heating is measured in each of the six buildings, and the total heat use was 17 GWh during 2018.

Price for electricity, both historical and day-ahead, are available from Nordpool free of charge. API:s for prices, historical and day-ahead, are also available for free.

Emission values for electricity are available from electricityMap. The supplied data is in carbon dioxide equivalents (CO_2eq); that is, all types of emissions are converted to carbon dioxide emissions based on their respective greenhouse effect. Two data sets have been used: marginal emissions in Sweden and imports to Sweden. Data for emissions forecasts from electricityMap are available via API:s. In this work, historical data for emission rates of margin and imported electricity have been used. For imported emissions, only the average emissions are available and not, as preferable, the marginal emissions.

Emissions data for district heating comes from the heat production department at Öresundskraft. There are three main heat production supplies: industrial excess heat from the chemical industry in Helsingborg, waste-to-energy combined heat and power (WTE CHP) and biomass CHP. There is also a heat pump that uses heat from sewage water and a fossil heat-only boiler (HOB). The district heating network is also interconnected with four other cities: Landskrona, Lund, Eslöv and Lomma, all located south of Helsingborg.

Energy Improvement Circle Tool applied at the Helsingborg Hospital Area

In the case study of the Helsingborg Hospital Area, the potential savings is €10,000 (1.3%), and €8,700 (6.6%) for electricity as well as district heating. This only refers to the heat power fee and not to the entire heat cost. The CO_2 reduction potential for electricity is 100 tonnes (5%) CO_2eq and for district heating 60 tonnes (3%) CO_2eq. in other words, the total savings potential is €18,700 and 160 tonnes of CO_2eq emissions annually in the Helsingborg Hospital Area. This is based on existing energy supply from 2018.

Description of the Power BI model

To illustrate how to evaluate the benefit from an economic and environmental point of view with the Energy Improvement Circle Tool, a model has been built in Power BI, standard Microsoft software. The Power BI model has four views:

1. Electricity overview
2. District heating overview

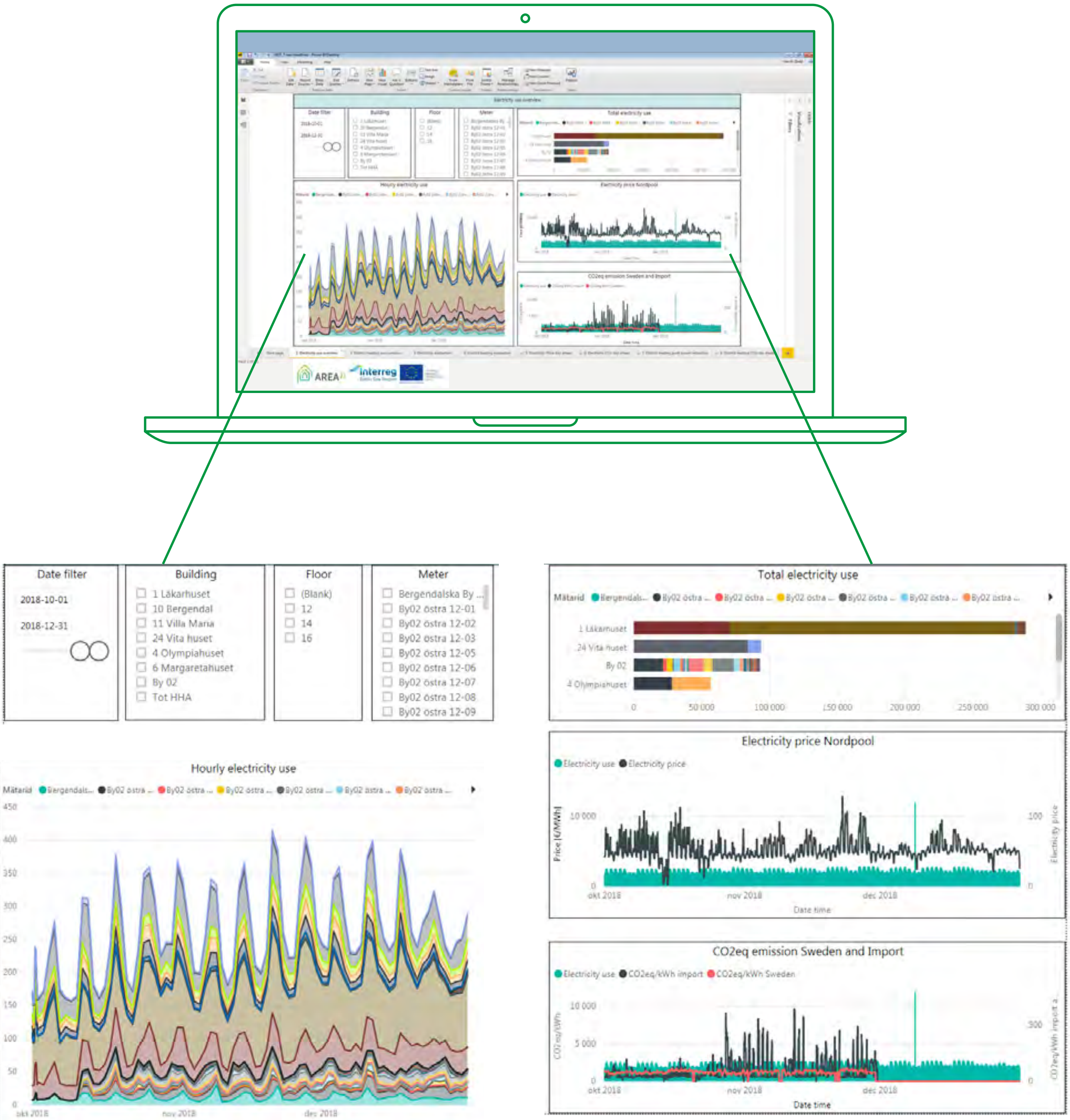
It gives an overview of electricity and district heating use, but also the option to drill down in detail. On a time scale, down to the hour, and on the energy volume scale, down to whatever sub-metering is available.

3. Electricity evaluation
4. District heating evaluation

It offers an evaluation of possible benefits both from an economic and CO_2eq reduction point of view.

Figure 17 (next page) is a screen shot from the model and shows the “Electricity overview”. For detailed information, refer to the Energy Improvement Circle Tool at the AREA 21 project homepage.

Figure 17: Electricity overview used in PowerBI model of the Helsingborg Hospital Area.



Discussion

There is an ongoing transformation in the energy system from fossil to renewable energy supply. Renewable energy sources like wind and solar create more volatile prices, and negative prices for electricity have already been seen a few times. Storage is one way to handle this problem, and large-scale electrification of the transport sector could be part of the solution as the batteries in the vehicles could be used not only as energy storage for the vehicles themselves but also as a storage service. Another solution is to use technology with a flexible way of using electricity to match production, to move electricity demand from times with low production and high demand to times with high production and low demand. An obvious advantage to this method is that it doesn't require investment or material use in batteries.

The Swedish district heating market is saturated and the amount of sold heat has not increased in a decade. The new buildings that are connected compensate for energy efficiency measures in existing buildings but don't increase sales. Historically, an oversized CHP or boiler was not a problem. The oversize would not last since the demand increased over the years. The base energy source for district heating is waste, biomass and industrial excess heat. All residuals from different processes have a low cost, but every saved MW of new built production saves €100,000 in investment cost. As for electricity, heat power is cost driving, not energy.

With a more volatile electricity price, and when the cost for district heating moves from fuel to the actual investment in heat power, there should be a shift in focus from saving energy to saving electricity and heat power. A tool such as the Energy Improvement Circle Tool supports this transition to improve the system of energy efficiency and thereby maintain competitiveness.

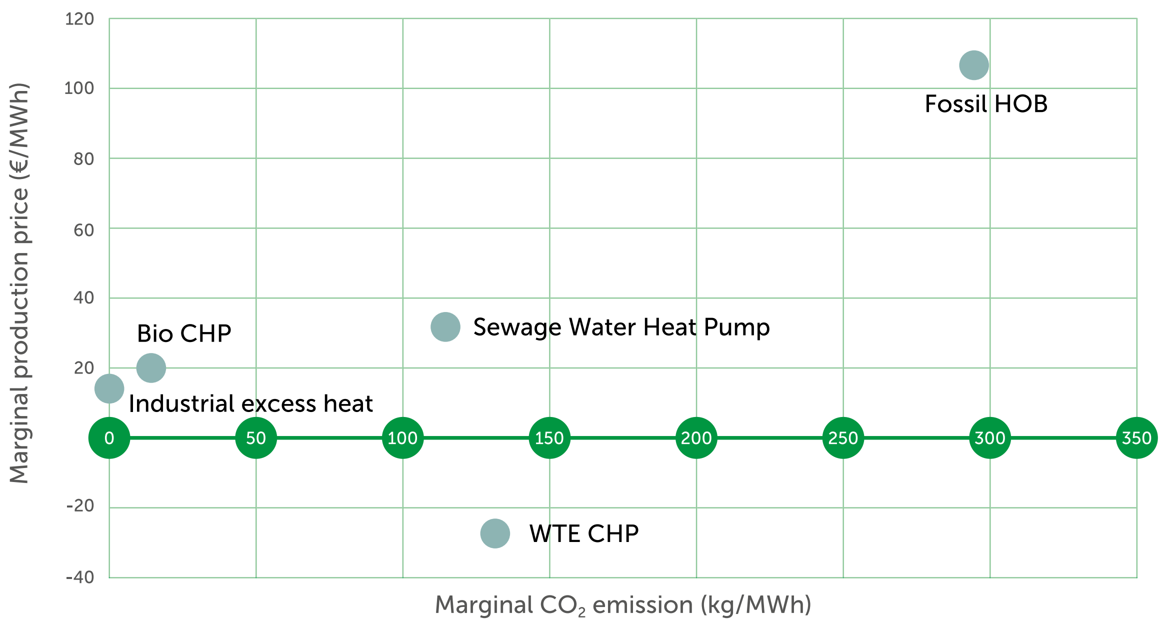
Price vs climate

An obvious risk is if the incentives of saving money and saving the planet contradict. Therefore, an important issue to analyse is to how price and emissions correlate to each other, and if there is a difference between heating and electricity.

Correlation between price and CO_2 emissions in district heating

Figure 18 below show the relation between production cost and CO_2 emissions for different heating units. There is an obvious correlation between cost and CO_2 emissions.

Figure 18: CO_2 emission and production cost for Helsingborg district heating system in 2018.

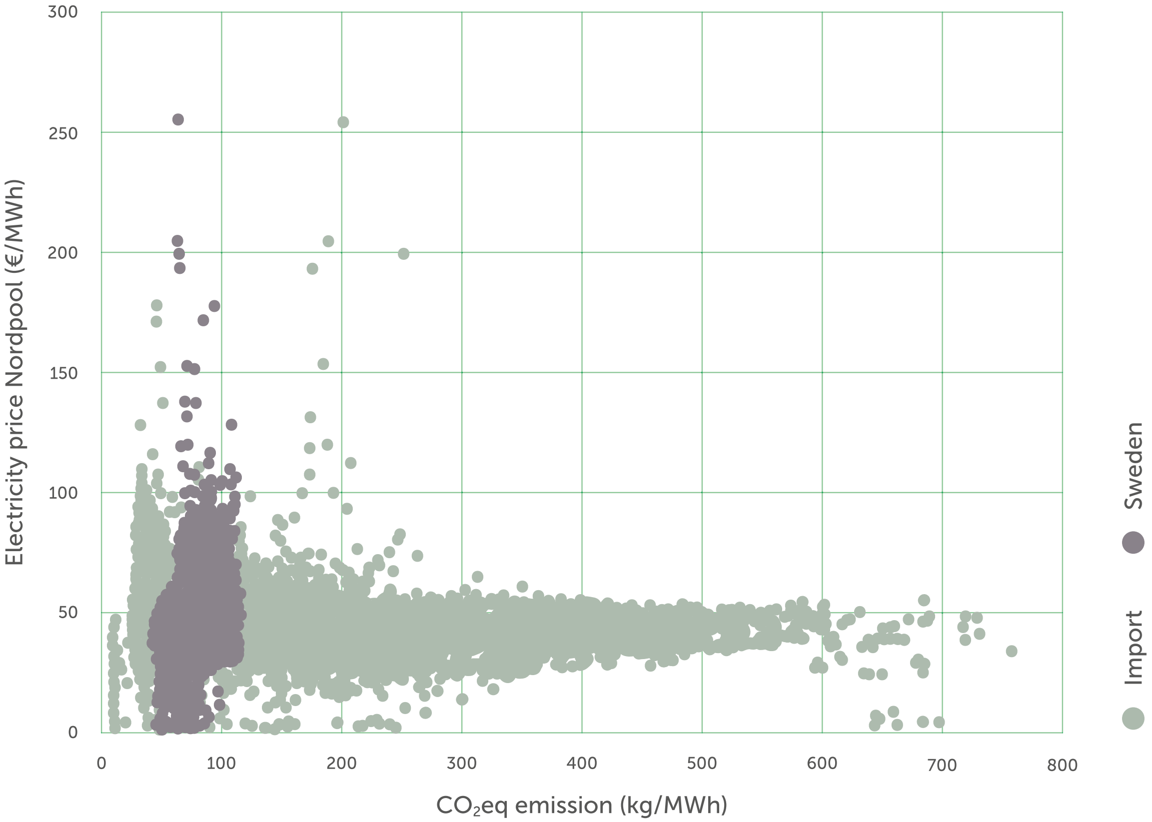


The fossil heat-only boiler is the most expensive and most emitting unit, and thereby not contradictive in the choice between cost and emissions reduction. The main contradiction is for the waste-to-energy combined heat and power units, WTE CHP, where the CO_2 emissions are higher than the Bio CHP but the cost is lower. The CO_2 emissions from the WTE CHP originate from plastics in the waste, and the stumbling block in Sweden is if this should be allocated to the waste collective or to the energy collective. For now, it is allocated to the energy collective and thereby causes relatively high CO_2 emissions for heating. The cost of emitting CO_2 is rather high because of CO_2 tax that was introduced in 1990 and is about €100 per ton in 2019.

Correlation between price and CO_2 emission electricity

In Figure 19 below, the correlation between price and CO_2 emissions for electricity is illustrated. The green points are imported electricity and the purple points are marginal CO_2eq emissions in Sweden.

Figure 19: Marginal CO_2 emissions (domestic production and imported) and market price for electricity in Sweden in 2018.



It is obvious that there is no correlation between price and CO_2 emissions. This means eliminating high CO_2 hours doesn't interfere with economic matters. On the other hand, it does not support it either.

In the future, with more intermittent energy supply, there are reasons to believe that the energy market prices will be more volatile, which will result in an increased benefit from electricity and heat power reduction at high load hours. The method can be one tool of many to support the work in meeting the new energy system. Working with power reduction and not only energy use reduction is an important step to a sustainable energy use.

To learn more about the Energy Improvement Circle Tool read the full report, which is available at www.area21-project.eu/ict-tools.

3.4

Comparative analysis of tools

Antti Roose

Comparative analysis of tools

Despite the AREA 21 tools serving urban districts in energy planning and management, the applications are different by purpose, structure and function. The benchmarking tool indicates the energy consumption in buildings, targeting the residential sector and supporting decision-making in choosing a feasible renovation scheme. The energy monitoring tool combines unique hardware and software for real-time energy, water and indoor climate monitoring to explore energy consumption patterns and support optimal energy consumption. The energy improvement cycle tool enables energy management and automated control over the demand response and peak load in the hospital energy system. Below, the key features and functionalities are evaluated in the light of best practices, similarities and differences as well in the light of benefits and replicability. The main categories which guide the reader through the stages of tool objectives, served needs and development are presented with information about the interactive, monitoring, and project tools. The tools target existing buildings so the system and modelling algorithm presumes a certain building design, energy infrastructure, range of energy usage and saving measures. The tools are not so intelligent for us to provide guidelines on how certain measures and instruments can be implemented and effectively inserted within the energy management system or if the energy management system and building require major improvements. There is the ability to interact with other policy instruments, such as a renovation grant or energy market measures.

Interactivity

All the tools are interactive, providing an instant calculation and evaluation of energy usage. This enables the user or decision-maker to take a proactive approach to energy management. The AREA 21 tools incorporate complex algorithms, which process the input data, run pre-defined analyses and generate results. These are characterized as software tools, online visualization platforms, energy models and simulation software. The benchmarking tool is available to all registered users via the internet. However, the usage of other tools is limited. The energy monitoring tool is installed in Tampere and requires the designated hardware and information infrastructure. The energy improvement circle tool is set by Östersundkraft using the automated data input and specific energy management system. The latter two are professional energy management and monitoring tools which need to be integrated into the building system.

Monitoring

The basic functions of the AREA 21 energy tools are evaluation, monitoring and tracking of the progress of energy consumption, taking into account certain baseline conditions, building parameters, operations and practices. These parameters are energy saved, GHG emissions avoided as a result of the energy efficiency measure, investment cost, and the return on investment or monetary saving rate. The resulting position needs to be compared to the baseline, i.e. the situation prior to the intervention and taken actions. The benchmarking and energy improvement cycle tools include the option to construct scenarios, which can be used for exploring the potential effects of different measures and energy usage patterns. The benchmarking is very useful to demonstrate the progress of the actions and provide feedback to the energy users and energy managers.

Project management

The AREA 21 tools help professionals to design and program energy management measures or renovation building projects; calculate building energy performance directly or indirectly; simulate the effect of various building sections as flats or departments, subsystems, components and technologies; and estimate potential savings by operational, engineering and investment measures to increase energy efficiency.

Table 1: The comperative analysis of the AREA 21 tools.

Feature	The bench-marking tool	The energy monitoring tool	Energy improvement cycle tool
The tool engages the user to establish 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/room	● ●	● ● ●	● ● ●
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 progress	● ●	● ●	● ● ●
The tool is used for benchmarking and reporting	● ● ●	● ●	● ●
The tool supports an energy demand forecast, optimization and control	○	○	● ● ●
The tool formulates tailored tips on how to save energy at the apartment, building or district level	● ●	●	● ●
The tool supports energy auditing and issuing a certificate	● ●	●	●
The tool provides energy consumption data at the appliance level	○	● ●	● ●
The tool integrates indoor climate (temperature, ventilation rates, humidity, CO_2, etc.)	○	● ● ●	○
The tool is easy to use	● ●	● ● ●	● ●
The tool has some form of social media connection.	●	●	●

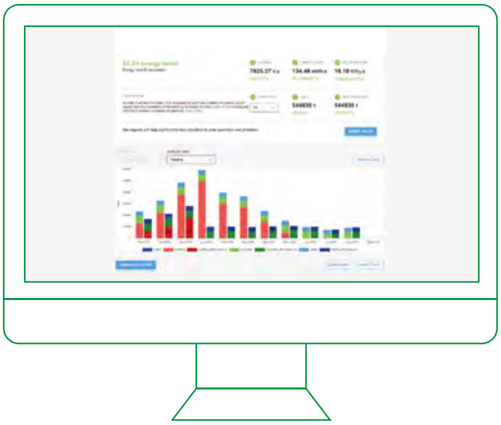
● ● ● Very much ● ● Somewhat ● Not really ○ Not at all

The tools support the implementation of measures for which concrete actions need to be taken. The tools provide accurate and trusted information in the form of tables and graphs to explore the progress and hidden obstacles for fostering energy efficiency in buildings while initiating and executing the projects and single operational measures. As measures have been implemented, tools can also demonstrate the resulting performance of a new, higher level of energy efficiency. The lessons learnt can assist in the implementation of similar cases for energy-efficient design and renovation measures. The operations of the energy monitoring tool provide recommendations for system design to streamline and optimize the current system architecture and monitoring technologies. The energy improvement circle tool offers various energy usage patterns conditioned to the specific peak or low demand, pricing or complex cases. Obviously, it should be verified by the calculation algorithms of tools and supported by the energy infrastructure in a systematic way and using universal standards.

4

Summary

The AREA 21 project developed three new ICT tools for implementing energy-efficiency measures, optimizing energy consumption and benchmarking progress in Energy Improvement Districts. This guide presents the development and implementation of those tools. It also features the best practices and applications in the field of participatory ICT-based energy planning and management, primarily from the Baltic Sea Region.

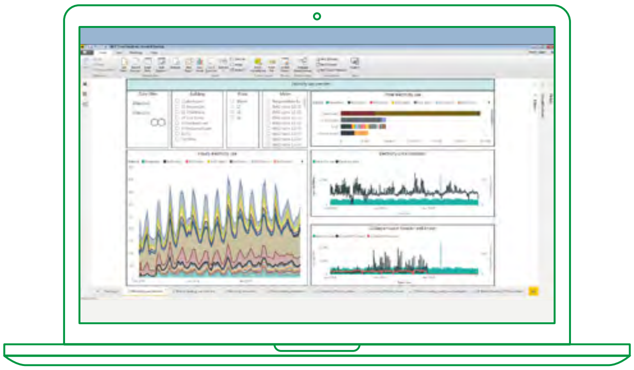


The 'Energiamonitor' benchmarking tool provides a comprehensive toolbox to store, analyse and assess a building's energy consumption and costs, enabling the user to get a better understanding of the building's maintenance, energy operations and savings potential. It can be used as expert system for choosing the renovation scheme and installing PV. The tool was developed by the Tartu Regional Energy Agency and the NewTime software company. The tool, which is supported in four languages (Estonian, Russian, English and Polish) was tested in Tartu and Kohtla-Järve in Estonia; in Lublin, Poland; and in St. Petersburg, Russia.

The energy monitoring tool features a system that measures building energy and water consumption and the conditions in real time. The holistic system tool is based on the use of connected devices to make informed decisions based on knowledge. The knowledge for the dwelling inhabitant is derived from real-time information that is the contextualisation of data for apartment life, which is from connected (IoT) devices in the apartment, dwelling, and local energy system.

The tool provides instant feedback to the user or flat inhabitant in the form of raw data, key performance indicators and graphs. The tool is applied at an apartment level and whole building level by tenants. The tool was developed by the Tampere University of Applied Sciences and was tested in a student dormitory in Härmälä, a district in Tampere, Finland. Härmälä was the pilot energy improvement district in the AREA 21 project.

The energy improvement circle tool is a developed method to analyse the potential savings for heat- and electricity peak power on a district level. The tool combines the management of local energy production, heat recovery systems and energy consumption into one energy improvement circle. Demand response solutions provide a solid platform for promoting optimal energy consumption and a new culture of energy management. The method has been applied in the Helsingborg Hospital Area, the EID pilot district, Sweden. It has been developed by Östersundkraft AB utility company, which supplies electricity, district heating, natural gas, and district cooling for end users.



These tools were tested extensively in pilot energy improvement districts as well in other urban districts in Estonia, Finland, Sweden, Poland and Russia and succeeded in being able to be applied and functional for end users, energy consumers and managers. By using tools and their interfaces to collect and make data visible, the amount of data for the energy user-citizen increases. Users can easily combine the data and visualize to see trends and keep track of energy consumption depending on uses and functions.

The conversion of data into knowledge. The example looks at the simple decision of using electric energy. Imagine you want to switch the major household energy consumers such as the washing machine and dishwasher. You know that the price is lower during the night, though you don't know the real-time electricity price and energy consumption of washing programmes. Or you may have analysed last month's electricity bill. The tool may suggest when to switch domestic appliances to save energy and money. The data is the real-time electricity price and energy consumption rates of appliance programmes. The knowledge is knowing when to switch on appliances or turning the heating or other energy-consuming household systems to automatic regime.

The following conclusions can be drawn from AREA 21 tool development and testing.

1. Based on the listed tools and testing experiences in the pilot districts, it can be concluded that ICT tools support climate policy and energy efficiency objectives. The strength of the tools is demonstrated by interactivity, monitoring and project initiation and management. However, their applicability is limited depending on the scope, user needs, data availability, engineering implications, hardware-software complexities and end user/consumer awareness and skills.

2. The systematic approach to energy planning and management using ICT tools is especially important because it offers predictability and evidences and raises the awareness of stakeholders involved.

3. A major benefit of the use of energy tools are comparisons and benchmarking measures as well as direct financial and monetary links for energy measures and savings. That's why, if possible, the tool should be related to invoicing and billing.

4. The introduction and deployment of tools should be more closely related to energy efficiency programmes and investments. It should be an integral part of the urban processes in the district and energy management system. And when introduced, the tool is used to evaluate energy performance with regard to very professional and specific aspects which may confuse non-professionals and citizens.

5. The initiation phase, when the design concept and the use and functions of tools are defined, is critically important to enable the full potential and establishing end user-friendly interfaces and functionalities.

6. The programming stage is also complex, though the risks can be grounded by agile and flexible project management and teamwork.

7. What also has been learned during the execution of the tool development and testing is that by visualizing the performance scores, the complicated engineering system and complexities of energy consumption can be explored.

8. A strong benefit is that the use of ICT tools gives the user and energy manager the means to communicate with stakeholders about energy performance, sustainable energy consumption and the maintenance of building operations. This can be very valuable during discussions with stakeholders about difficult subjects such as energy investment or building renovation and reaching an agreement with housing associations, energy operators, and financial and municipal institutions.

What do energy tools mean to us and how will they impact us? They will make everyday life much easier by creating efficiencies in energy, household and domestic operations. With IoT, AI and machine learning, we have the data, information and knowledge, and smart citizens behind them, to create meaningful solutions. Smart cities could be the link to a more sustainable, circular economy. Urban investments should become climate proof. By having the ability to gather energy consumption data, the information gains visibility and in turn can make knowledge-based decisions and minimize or even avoid negative externalities.

In conclusion, the AREA 21 project observed that ICT tools can be very useful in facilitating participation processes, motivating stakeholders, understanding systems, provoking conservative bodies and initiating urban transition. The tool-related actions in the AREA 21 project showed that, having sufficient time and finances for two years of operations, progress in the participatory ICT tool-supported energy planning can be made that has a much wider-reaching impact than would be expected from a single experimental ITC tool.

Having experimented in three different urban districts, deploying three different tools, the developers learned and acknowledged end-user reactions and behavior. It was highly valuable to understand motivations, patterns and daily practices of citizens and end users in the contexts of energy management, the ICT learning curve and user feedback. The most challenging and exploratory part of this action was how ICT tools in energy planning and management advance a more sustainable way of living for smart citizens and the smart city in general.

At the urban district scale, urban energy innovation offers new-generation heating systems which include low-temperature heating supplies, improved heat transmission infrastructures, heat recycling, and building innovations such as smart metering, floor heating, heat exchanges, and adaptive indoor climate controls. Combined with smart energy technologies such as variable renewable technologies, for example, PV panels, energy storage and intelligent control systems, smart urban energy systems encompass a wide range of technologies that need to be coordinated in the urban governance enabled by open and inclusive participatory modules. The urban energy system integrate already district heating with the electricity system. The process innovation using ICT tools and automated solutions model sustainable cities.

5

A Simple Guide

Urban guide

- Smart cities are typically technology driven. Engineering comes first. Understanding residents' needs and improving quality of life should be important. Start with the thermal comfort and indoor climate! Urban citizens want to solve their problems.
- Focusing on the building stock is essential for achieving overall reductions in energy consumption in cities and urban districts.
- It does not matter how much energy hypothetically and potentially could be saved by renovation and efficient technologies if the behaviour of households and energy users in reduction is not addressed.
- By giving feedback on energy consumption as well as indoor climate, the ICT tools can assist households in changing their behaviour and save energy.
- The awareness loop of the energy consumer begins with monitoring and continues with acknowledgment of problems, which converts to anticipated change in installation, technologies and behaviour.
- Be aware! Energy savings in terms of energy and money can differ in great extent depending on energy tariffs.
- Reduction in peak load using real-time applications balancing demand-supply should be focused on in developing smart energy management systems - no matter whether you are an urban network operator or household.
- Privacy issues must be a critically important consideration for the energy monitoring tools in the case of real-time tracking and comparison between households.
- Customised graphs tell you when and how you have to act for energy savings.
- Run your energy management with the application.

Developer guide

- Before starting to develop the energy planning and monitoring tool for the urban district, first, you should explore your own domestic energy consumption and the effectiveness of current energy applications.
- Before starting to develop an energy-planning and monitoring tool for an urban district, you should hire experts and professionals dealing with sustainable building/housing and environmental psychology.
- Should the ICT tool developer understand factors influencing the use and effectiveness of energy planning and monitoring? A certain level of knowledge is needed.
- When it comes to monitoring, provide attractive and clear graphical visuals on indicators and change. One picture tells many stories so please emphasis on key stories from end-user perspective.
- The launch of the tool is always delayed, usually due to data and fine-tuning reasons. Quality takes time.
- Resources should be planned and allocated for maintaining and updating tool to ensure that the tool is sustained in the long term.

Energy planning and monitoring

in the urban district. The reality.

Participatory planning

End-user / customer centred approach

Improving energy effieciency

Smart building and technological innovation

Enabling the ICT tools and applications

Social innovation

Activating citizens

Joint decision-making on public interest

Adapting to climate change

Cutting the energy bill

Saving energy

This book aims to guide urban policy makers, technical experts, housing associations, citizens and other relevant stakeholders through the key principles and steps of designing and developing energy management tools by presenting the AREA 21 tools, helping them to use ICT tools to increase energy efficiency in buildings and for participatory planning in urban districts.

area21-project.eu

People identify with their neighbourhoods. Learn from AREA 21 energy improvement districts and energy planning tools which have revitalised their districts, developed applications for district-scale intelligent and smart energy management and decarbonised the city for the greater good.

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Interreg Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND