Ex-post evaluation of AREA 21 ICT tools

Report

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By

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Cover: The screenshot of the benchmarking tool

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ABSTRACT

This report summarises the post-project evaluation of ICT tools developed and disseminated in the Interreg Baltic Sea Region project AREA 21 between 2017 and 2020. The three ICT tools continue to be used and disseminated in the follow-up project AREA 21 + action – and against this background, an ex-post evaluation has been carried out in autumn 2020 – winter 2021. The report was drafted by Antti Roose (activity chair) and Marten Saareoks (Tartu Regional Energy Agency), Kari Kallioharjo (Tampere University of Applied Sciences), Anna Sundberg (Öresundskraft AB) and discussed in multiple stakeholder communities such as inhabitants, neighbourhood activists and urbanists, municipal officials, energy consultants and auditors, energy operators, software developers, academic researchers etc.

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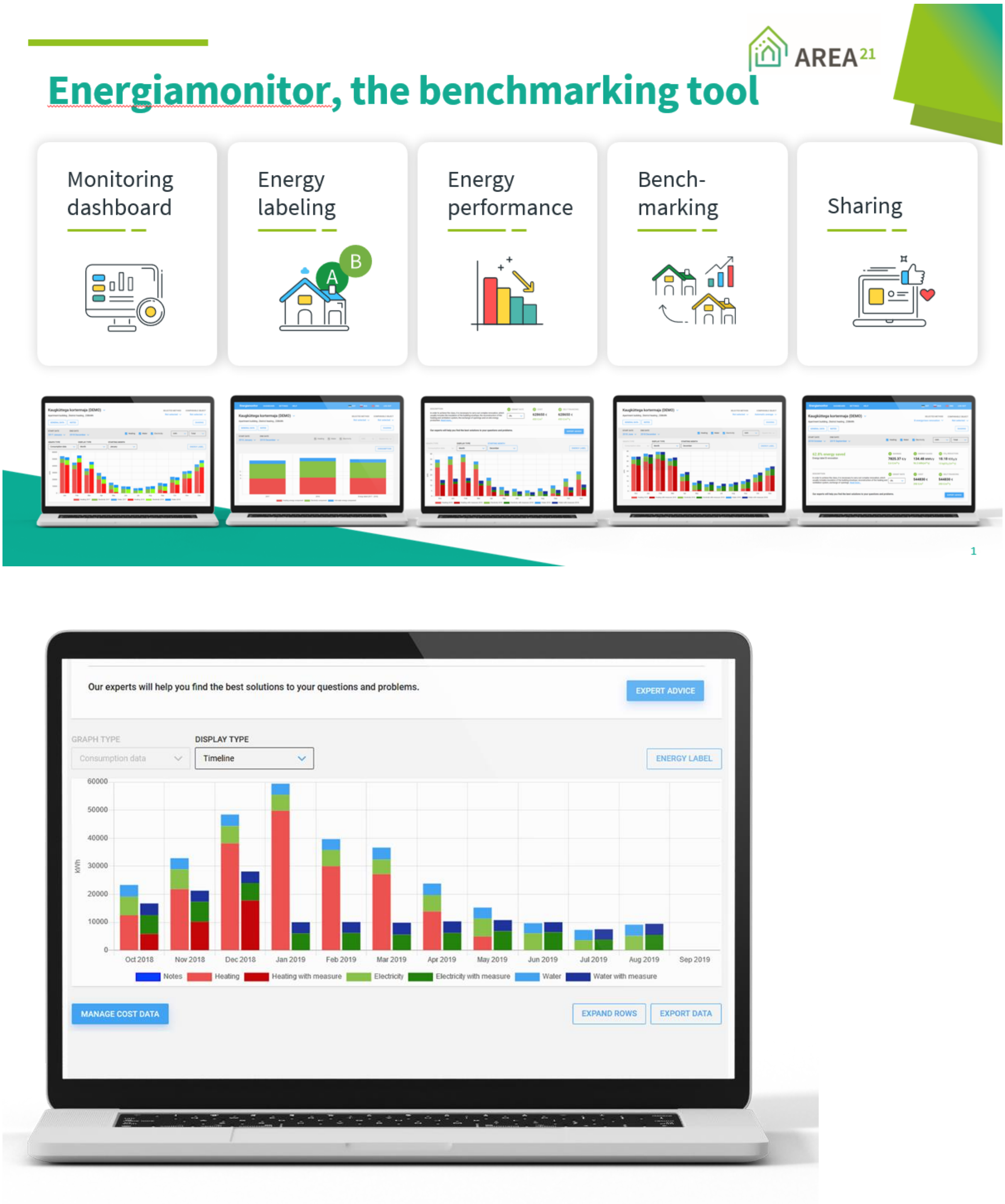

Figure 1. The system overview and the interface of the benchmarking tool (Source: AREA 21 project)

1.1. Delivery, promotion and use

Evaluation approach: monitoring of usage, robust assessment of data quality, securing personal data protection, use of the tool for backcasting, forecasting, interpreting for engineering, monitoring and other purposes, promotion of the tool

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 analyses 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 to consult about energy efficiency or building reconstruction.

The application is intended to be used by owners or managers or real estate users interested in energy consumption and savings at their site.

The application's user interface supports four languages: Estonian, Russian, English and Polish (special interface).

The development of the Polish version of the application has been stopped after facing major legal and institutional obstacles with personal data protection. The team had to discontinue upgrading and changing the Energiamonitor and "freeze" it in the current "in-development" stage hidden behind additional passworded access.

The benchmarking tool functions in the following modules:
(1) Dashboard:

- Data input and monitoring : Mandatory input, automatic input integration based on energy provider databases was not possible at the time of development, nor feasible.
- Division of space heating and hot water, if same energy source is used for both, need to be specified (complicated for end-user households).
- The user manual of Energiamonitor is available in all languages and an excel data input assistant has been composed.
- Billing and energy units diverge (not harmonised).
- The non-monetary approach is more important.

(2) Energy labelling: An unofficial label based on the Estonian energy labelling methodology has been applied. Energy labelling varies by countries, values and conversion factors are revised quite often by the legislators. The benchmarking tool focuses on the evaluation and labelling of residential buildings.

(3) Energy performance upgrade/renovation module: the tool uses an Estonian model case related to energy labelling and construction prices in Estonia.

(4) Benchmarking module: The dataset is still small and includes only a few similar buildings; it is not applied very often. Manual selection is constrained by anonymity requirements.

(5) Sharing module: This module is functional, it supports exchange and joint actions.

Entered data can be used to analyse trends, conduct surveys and create summaries for publication while granting user anonymity.

The benchmarking tool is promoted at multiple workshops and seminars on housing renovation and energy efficiency. Moreover, it is featured on the landing page of the TREA website (www.trea.ee) and via social media (Facebook and Twitter). Furthermore, the benchmarking tool invites other pilots and projects to contribute with the input of data and evaluate and benchmark energy consumption.

Data access is complicated due to the billing and energy management systems. Various data restrictions occur for energy end-users. Energiamonitor has currently 66 users with 135 objects.

1.2. Quality

Evaluation approach: summary of views and comments of insider and outsider (independent) sources (based on feedback sources and enquiries, using interviews, end-user experiences, (ad hoc) meetings of stakeholder groups).

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

- **Data Input**: simplicity and clarity – In the initial object registration, seemingly too much information is asked, even if not all fields are 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.
- **Data quality**: Minimum full-year data required – Joint monetary and energy evaluation causes various data quality problems (hot water). The data quality tends to be poor if the same energy source is used for producing hot water and space heating. Water input can be excluded, but electric energy and heating energy consumption are mandatory.
- **Performance issues and bugs**: In the application's navigation, graph and tables design and clearness of the results are overall on a good level. However, it is still important to improve and increase accuracy. In certain situations, the application refreshes the page after different selections. There is a bug in the renovation module which occurs when changing renovation schemes related to keeping the initial period, unit and energy sources in the dashboard. With regard to energy labelling, the heating energy component in some cases tends to show increased values for most recent years. Heating degree days check displays unduly raised values for recent months related to summer months accounting. Problems were highlighted and solved in the excel files on which the calculation in the source code of the application is based. However, due to complicated and fuzzy

algorithms, it is challenging to fix these issues. Due to anonymous data requirements and objects database, the benchmarking functions are available only in some cases.

- **Texts and translations**: Accuracy and clearness in the text and layout of the translations could be improved.

1.3. Innovation and follow up

Evaluation approach: How does the tool add to the general progress in the scene of energy tools? What are the prospects and ideas for the user interface (UI) for improving user experience (UX)? How could functionalities and data input methods be optimised in potential follow-up initiatives? How to integrate and progress big data?

Automatic (database-database) energy data input is urgently needed to simplify use and data quality. Automatic data input of all Estonian connected consumers' electricity data is possible, and for natural gas, it is foreseeable soon. For district heating, a centralised user database is planned in the longer term. For other fuels and hot water, automatic data input is neither foreseeable nor feasible.

In the smart city portal being developed by City of Tartu (based on the Cumulocity data platform), we are already working and studying the integration of various meters and databases, including energy service providers' databases. It is an open-source data platform, and the creation of integrations and data use in other applications should be possible in the future.

Dissemination is going to be launched in Latvia and Finland. Testing and piloting continue in Estonia and Russia. Reservations should be acknowledged and discussed. The energy label has been calculated according to the Estonian regulation's methodology (energy labelling, energy carriers weighting factors). The application defines 6 Estonian climate or degree days regions (normalised heat usage, energy labelling). In energy-saving, options are connected to Estonian energy label classes, and construction costs are Estonian averages. In the energy-saving options, PV panel production is based on Estonian location.

Programme development: General application bugs should be resolved (see above).

A broader range of user countries and cities should help identify more detailed errors and problems and additional specific cases. It is also recommended to collect and list all concerns and start collecting user activity feedback with automated applications.

2. ENAP: The Real-time Energy Monitoring Tool / Holistic System Tool

Figure 2. The system overview and mobile application interfaces of the real-time energy monitoring tool (Source: AREA 21 project)

2.1. Delivery, promotion and use

The Real-time Energy Monitoring Tool, also referred to as "Holistic System Tool" or "Energy application from TAMK" (henceforth "ENAP"), is a service for monitoring and analysing real-time electricity and domestic water consumption and indoor conditions in apartments and single-family houses. The tool has been developed by Tampere University of Applied Sciences (Finland). ENAP monitors apartments electricity and domestic water (hot/cold) consumption and indoor conditions (temperature, CO2, humidity) and visualises real-time data in dynamic trend line graphs. ENAP can be used by apartment owners or tenants to monitor their apartment's indoor condition and energy consumption. Moreover, it aims at triggering behaviour change of energy consumers.

The tool includes sensors and third-party system interfaces, a data routing system, data servers and a web-based user interface. The user interface and software coding notes are in English to ensure openness, possibilities of further development and replicability. User data is secured via personal, password-secured accounts and data is stored on TAMK's own servers. Written agreements between participating users and TAMK are in place regarding data processing in ENAP. Data is strictly limited to the purposes of the tool and not intended for any other use.

The current version of ENAP is v 1.0.16 and it includes:

- data interfaces for FTP protocol and Lora IoT devices
- data storage
- user interface with basic functions and instructional features
    - overview of building monitoring
    - overview and subpages of apartment measures with dynamic info graphs and tables
        - indoor conditions
        - electricity power and domestic water consumption
    - limited data history monitoring
    - feedback channel

Some of the features planned in the tool and in the user interface during the project were postponed because challenges with third parties required more resources than planned in the beginning. ENAP is being promoted in workshops, seminars, f2f meetings and discussions with different stakeholders. It is moreover promoted for other pilots and R&D projects. ENAP is currently installed in two building sites in Tampere.

2.2. Quality

During the development and piloting process and further discussions, all observations and challenges have been listed and analysed. The main observations are:

- **Service organisation:** Besides the tool development, resources for ENAP maintenance and user services are required. Hardware and software need continuous monitoring and maintenance, and user and security issues are laborious (e.g. user support and training and removing, adding and updating tenant accounts and GDPR agreements). Specified staff for these tasks is required.
- **Sensor's reliability and data quality:** Sensors reliability (incl. data transferring and sensor battery lifetime) must be improved. Wireless technology range (coverage) and connectivity is not reliable enough, especially in the apartment house basements where the electricity meters are located. This leads to partially fragmented data, which is fixed by algorithms in the current ENAP version. Poor connectivity affects sensor battery duration. Theoretically, the sensor battery should last for years, but in some sensors the battery lifetime currently amounts to just a few months.
- **Software performance:** The user interface login has been down too often, servers and their reliability need improvements. Maintenance alerts for dropped sensors need to be developed. Administrator and building owner (energy planner) user interfaces should be established (centralised desktop: helpdesk centre, user account and GDPR agreement administration, centralised building and apartment level energy and indoor condition monitoring, data download and reporting services, system maintenance alerts, etc.).
- **User interface:** Monitoring indoor conditions is a feature of ENAP that is appreciated by the users. However, the monitoring history and trend logging time range for data is limited and should be developed further. A historical data download option is required. Instructional (energy guidance) and comparison features need to be developed due to limited user knowledge. Users would also like to see more accurate energy consumption data for different appliances (e.g. washing machine, dishwasher, stove).

2.3. Innovation and follow up

Service organisation and resources is a crucial factor for ENAP development and expansion of the user base. Several potential future projects at TAMK include the utilisation and further development of ENAP. Negotiations with the stakeholders about other development possibilities are under discussion. After the resource challenge for the development is solved, the development steps will include:

- expanding the user base to support the tool development in different levels and enable new research methods (e.g. quantitative) to validate the tool impacts,
- service model planning for better reachability of the tool to widen the tool user base,
- open data platform research and development and open data utilisation (e.g. weather data and building energy data) for better user experience and a future proof ENAP,
- multidisciplinary user interface development "ENAP 2.0" for better user experience and behavioural change (e.g. user interface re-design, smart suggestions features based on machine learning and AI,

instructional and comparison features, gamification, historical graphs and data analysis tool development, user support development),

- admin interface establishment in cooperation with the stakeholders (e.g. building owners and energy planners) for easier maintenance and support actions and for widening the tool usability in full (required features are e.g. centralised desktop including helpdesk, user account and GDPR agreement administration, centralised building and apartment level energy and indoor condition monitoring, data download and reporting services and system maintenance alerts),
- testing the tool in single-family houses and renovation sites for developing and widening the tool exploitation possibilities from the apartment owners to building owners and energy planners and enabling the research of impacts in different use cases.

ENAP IoT data platform development is an essential part of the development towards full replicability. Open data platforms and monitoring and controlling systems in energy communities (e.g. EID's) are currently studied and developed in the national Procem Plus project, where TAMK is one of the research partners. Testing and implementing ENAP in the Procem Plus data platform is planned during the project. A project application regarding the open data platform and data utilisation on a broader scope are also currently being developed with local stakeholders and City of Tampere. In the project application, tasks include e.g. integration of various meters and databases (e.g. energy service providers databases, Tampere building database and national building databases).

ENAP is a tool, which will complement open data and AI-based energy efficiency services in the future (AREA 21 + action WP2, A2.4, T1), and it is utilised in service development conceptualisation.

3. The Energy Improvement Circle Tool

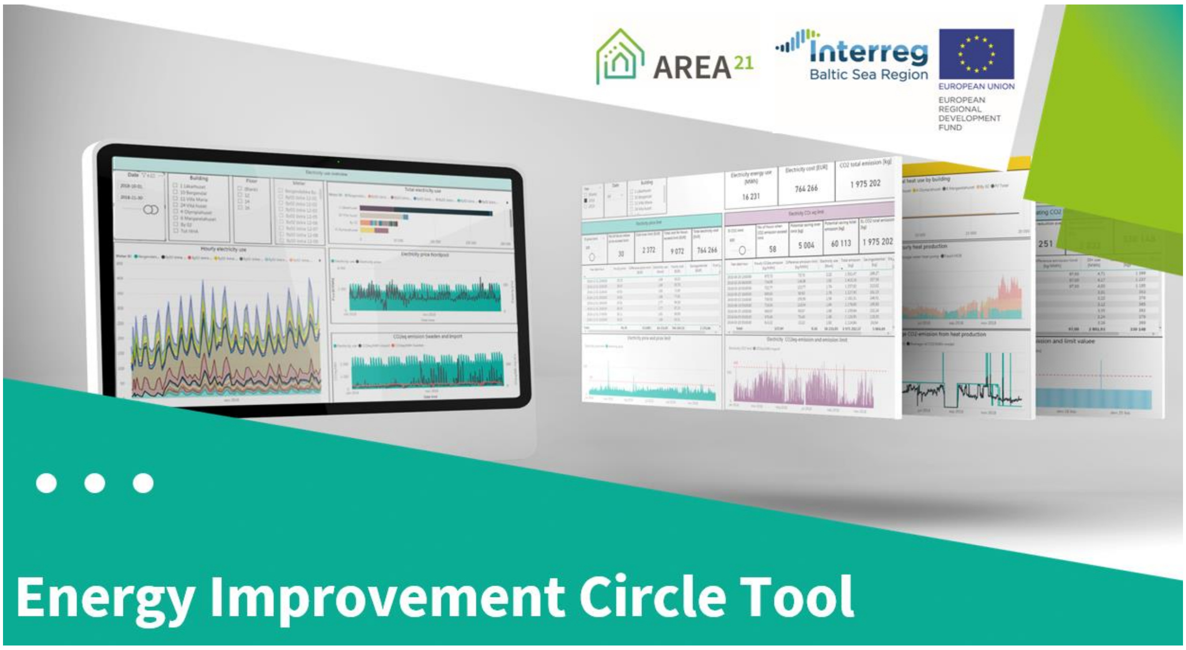

Figure 3. Interfaces of the energy improvement cycle tool (Source: AREA 21 project)

3.1. Delivery, promotion and use

The functions and method of the Energy Improvement Circle Tools are used on a daily basis in the work at Öresundskraft. The hypothesis that it is rather the power usage than the energy usage itself that will reduce the climate impact is still highly relevant, now more than ever. During the last year, Sweden has suffered from problems in power demand, and therefore analyses on this matter are highly important.

During 2020, the tool itself has been used in several dialogues with property owners and the City of Helsingborg. It has been a very pedagogical way of explaining the importance of working with power, both for solving the power demand problem and The focus on power usage has been especially high in the City of Helsingborg, where much work has been carried out in close cooperation with Öresundskraft – e.g. related to estimating how the power peaks will look like in the future when great parts of life, such as cars, will be electrified.

The Energy Improvement Circle Tool as a method has made it possible for Öresundskraft to gain a proactive position in the power demand work. To put such analysis on the agenda as early as we have done, much thanks to the AREA 21 project and its development of the Energy Improvement Circle Tool, has really been a game-changer. Now the City of Helsingborg and Öresundskraft are seen as one of the front runners in power demand work throughout Sweden.

In the upcoming work with the methods of the Energy Improvement Circle Tool, the analysis will be integrated with other data such as weather forecasts, energy usage from the surrounding system etc. This should enable the involved actors to estimate and plan a property's energy and power usage even further and achieve even greater climate and economic profits.

3.2. Quality

The Energy Improvement Circle Tool data is from the year 2018 but can be changed into more recent years if needed. Personal data protection matters are less prevalent for this tool. The presented data is general energy usage per time at a certain part of a building and cannot be related to any specific individuals.

3.3. Innovation and follow up

The plan is to further use the Energy Improvement Circle Tool methods, which is already in motion as described above. The focus on power usage and methods to analyse the climate and economic impact are planned to be implemented even more in the Helsingborg Hospital Area EID. During the AREA 21 follow-up project AREA 21 + action, actions of measuring energy power and visualisation of the energy usage are to be performed, and therefore the knowledge and analysing methods from the tool will be useful.

During the last year, the same approach of using climate data together with a general "power peak focus" has been used also towards the private customers of Öresundskraft (the Energy Improvement Circle Tool tool targets mainly property owners). This has been carried out by developing and implementing an energy-saving app for end-users that visualises both energy usage and carbon emissions. This app should also enable private smaller households, such as villas, to be more energy-efficient and reduce their carbon footprint.