ACTION FOR ENERGY EFFICIENCY IN BALTIC CITIES

ACT NOW!

Quality improvement of local energy management

Improved energy management systems

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Francesco Romagnoli – Riga Technical University;Mikko Himanka – CENTRIA PP;Adam Cenian - Szewalski Institute

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List of abbreviations

BMS	Building Management Systems
CAFM	Computer Aided Facility Managment
CBS	Capacity Building Scheme
CLAHE	Contrast Limited Adaptive Histogram Equalization
COTS	commercially available off-the-shelf
EnMS	Energy Management System

EE	Energy Efficiency
EEEF	European Energy Efficiency Fund
ELENA	European Local ENergy Assistance
EU	European Union
EUCF	European Union City Facility project
HVAC	Heating, Ventilation and Air Conditioning
ICTI	Information and Communications Technology
LEEG	Local Energy Efficiency working Group
MQTT	Message Queuing Telemetry Transport
ORC	Optical Character Recognition software
PP	Project Partner
RES	Renewable Energy Source
SWOT	Strengths, Weaknesses, Opportunities, and Threats
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
UI	United Illuminating customer

1. About this report

Putting into focus the lacking capacities in the *ActNow!* municipalities and the no one-size-fits-all solution approach, building one kind of capacity for Improving the EnMS may require different measures from case to case.

The starting point towards the proposed approach is the identification of key measures to be potentially implemented in a strategic local energy planning. According to the knowledge capacity building framework developed within the *ActNow!* the selection of technical solutions for energy monitoring and their implementation as investments is essential. This is reason why 7 pilot investments in 6 regions have been identified within ActNOW project in line with the developed Capacity Building Schemes developed in the municipality beneficiary of the investments (see actnow-baltic.eu/learning).

This report is organized as following:

- Description of GoA3.2 (Quality improvement of local energy management) and its outputs;
- Summary of the implemented pilot measures in Energy Management Systems (EnMS) within *ActNow!* project;
- Transnational values of the outputs;
- Further steps.

2. Description of the GoA3.2

The main goal of the GoA3.2 is the implementation of the capacity building schemes in the participating municipalities in the tandem approach established among a specific coaching expert partner and one municipality. Within such approach, the coaching expert partner and the formed LEEGs are responsible for implementing direct measures properly, also setting the frame for the on-the-job-training.

Specifically, in GoA3.2 direct measures proposed in training/capacity building schemes were used within a local energy efficiency strategy for buildings based on selected facilities as pilot cases. Real investments included local energy efficiency solutions in pilot cases for buildings in form of IT data acquiring and processing tools, monitor system types of equipment and/or individual retrofit strategy, in fact including Computer Aided Facility Management (CAFM). The scope of measures was to upgrade, or established new, energy management systems by integrating tools to increase the quality and efficiency of the municipalities' energy management meantime trough the tandem approach.

The benefit of the measures lies in improved the administrative structures and procedures, the effectiveness in the energy management and the overall municipal job condition. This was mostly reflected as a strengthening of the municipal competences enabling to work with new energy management tools aiming to specific investments within the project implementation.

3. The main output in GoA3.2

The main output of the group of activity 3.2 (*Quality improvement of local energy management*) is the implementation of new or updated EnMS in the participating municipalities tailored to the size and needs of each municipality.

With the support of the coaching partners in each tandem approach, the aim was to support municipalities on the selection of a proper EnMS aligned with energy saving and local energy strategies potentially including ISO 50001.

This process was implemented and harmonised with the capacity building scheme identified for each municipality. The purpose was to enable a more systematic and consistent decision-making process committing the municipality on the introduction of identified energy management systems.

In order to fulfil the defined scope of activity in *ActNow!* project the dedicated budget for investment was intented to promote increased energy efficiency competence of the municipality in question. The investment were oriented on the Computer Aided Energy Monitoring tools which must allow an energy monitoring in due time and make energy management much easier.

This gave an accurate reference for reflecting the investment plans according to the project intentions. The idea of the investment was not about increasing the energy efficiency of the municipality directly, but to provide better technological tools to make it as an internal process of the municipality itself. Therefore, the added value comes by the more efficient building management and maintenance processes with accurate real-time awareness of the situation. This aspect lead to a more far-reaching benefits than classical energy investment as such.

The investment process is part of GoA 3.2, and to promote it, a dedicated investment workshop was organized as a part of the consortium meeting in Gdynia in October 2018. During that workshop, the basic guidelines for the investment process were presented and the fundamental approach of partners was discussed. During the discussion the partners learned about new methods of Information & Communication Technology (ICT) based energy monitoring including Computer Aided Facility Management (CAFM).

In five municipalities (Gdynia, Silute, Gulbene, Elva and Sievi) were identified appropriate investments in equipment for smart metering, data transfer and IT based data processing. Similar investments were also planned from Russian Funding by PP 18 for Kaliningrad. PP 6 (Gdynia Trolleybus Company) carried a pilot investment which purpose to installation of Energy Monitoring and Management System in the form of computer assisted facility management in the building of the trolleybus depot. The partner installed a new ICT based metering to control the energy management of a facility. The summary of each pilot investment is in-depth described in the next section.

The coaching expert partners Project Parner (PP) 7 (Centria), PP 10 (Szewalski Institute) and PP 12 (Riga Technical University) have proposed software solutions for processing of energy consumption data in the coached investing municipalities.

4. Summary of the implemented pilot investments in EnMS

In this section are described the main outputs from the pilot investments in each participating municipalities including the Municipality of Kaliningrad and the trolley bus company of Gdnya municipality.

PARTNER	Focus of the investment
Sievi (FI)	Village school monitoring system
Elva (EE)	Energy consumption and indoor climate monitoring system for public buildings
Gulbene (LV)	36 Heating energy meters and 81 remote data reading systems in whole Gulbene municipality
Gdynia (PL)	Air condition data loggers with monitoring system for selected school building
Gdynia PKT (PL)	Energy Monitoring and Management System in the trolleybus depot
Kaliningrad (RU)	Smart city: Improving the existing EnMS through the introduction of an automated energy management system (modernisation in several municipal buildings)
Silute (LT)	Hardware adaptation and purchase of hardware + software for energy monitoring system in 5 public buildings

4.1. Sievi (Finland)

Heating consumption monitoring system with open implementation in rural areas

In Sievi, the biggest municipal buildings in the town centre have a comprehensive Schneider Electric building automation with cloud-based UIs and services. This allows to access the consumption data directly within the system platform.

On the other hand, the buildings in rural areas, the village schools in particular, don't have any monitoring solution so far, only local energy meter for billing purposes. Investments are divided to two phases. During phase 1, the movable energy flow metering system was bought, in order to provide deeper understanding of the building behaviour in circuit level. The first measurement campaigns have already been performed, and additional ones are planned together with Sievi technical department.

The phase 2 investment included then energy monitoring systems for the 6 village schools. The solution is based on COTS-based devices in order to provide continuity and product support also after the project. This solution.

In Sievi, the idea was to use the project EnMS for analysing the data during the project.

4.1.1. Summary of the pilot investment

Partners/Beneficiary involved: Ylivieska Region, Centria

Name of Pilot Testing Measure: Sievi municipality buildings

Location of Pilot Testing Measure: Sievi municipality

Owner of the investment: Ylivieska region

Coaching partner: Centria research and development

4.1.2. Background

Sievi municipality is a typical example of small Finnish rural municipality with a commune center and a number of villages around. The town hall, elderly care, biggest schools and health care units are all located in the commune center, and as new municipal buildings have been built, also building automation and related EnMS services have been renewed and consolidated to cover all main buildings under the same brand.

At the same time, there are village schools around the municipal area, which are mostly older and smaller buildings. They haven't experienced similar major revisions. The heating sources have been slowly changed from oil to ground heat or woodchip, as the direct payback time for that is evidently rather short. Otherwise, only punctual problems in the buildings have been renovated.

4.1.3. Main problem to be addressed

As the project plan describes, "investments in Computer Aided Energy Monitoring Tools have been carried out during the project which allow an energy monitoring in due time and make energy management much easier." This gives an accurate reference for reflecting the investment plans to the project intentions. The idea of the investment is not to increase the energy efficiency of the municipality directly, but to provide better technological tools to make energy efficiency improvement as an internal process of the municipality itself. Therefore, the added value comes by the more efficient building management and maintenance processes with accurate real-time awareness of the situation. This leads to the more far-reaching benefits than classical energy investment as such.

Investment process is part of GoA 3.2, and to promote it, the corresponding workshop dedicated to investment was organized as a part of the consortium meeting in Gdynia in October 2018. During that workshop, the basic guidelines for the investment process were presented and the fundamental approach of partners was discussed.

The historical evolution has led to the situation, where modern municipality center buildings provide modern building monitoring services and comprehensive cloud-based options for energy management, but village schools have been left outside of these developments. It also means, there has not been any method for real-time monitoring of energy consumption.

This affects also to the internal processes of the municipality, which are organized so, that all property assets are built and maintained by one municipality unit, which rents the buildings to other units such as education. When it comes to energy costs, lacks in consumption data don't encourage to any savings. If the building is being used by a one municipality unit, its administration will pay all the costs, and the actual users of the building are typically aside of this process. If the building is used by several

municipality units, the lack of data makes fair share of energy costs between units impossible. Instead, if billing is based directly on cubic meters, this does not stimulate much motivation for energy savings.

Therefore, the need is to provide temporal diagnostic measurements by such energy measurement system, which would be easy to install and move to different locations according to needs.

4.1.4. Aim and scope of the pilot investment

ActNow! project aims at better awareness of energy consumption and skills to analyze and execute beneficial energy actions on that basis. In Sievi case, village schools formed a substantial municipal building group, which lacked technological basis to execute beneficial energy actions. The first step is to deploy a system, which can collect real-time data from the major parameters of energy usage and deliver them to other processes for utilization.

The designed approach is based on local programmable logic controllers (PLC), which can be expanded with i/o units for connecting the required sensors. These school PLCs deliver all the collected data to the central server in the town hall, which acts as a main storage and hub for delivering the data to other services such as EnMS.

Based on tendering process, Beckhoff PLCs were procured and installed into school buildings as well as the needed sensor units. The main focus in this first-level deployment was in heating energy consumption. In every school PLC there are free analog and digital inputs available for additional sensors, which can monitor also electricity consumption, ventilation, hot tap water usage etc. Incorporating these additional installations is rather easy after this fundamental is up and running.

Openness is most important principle in all of this process. All interfaces and used protocols and file formats are open, which enables wide range of possibilities for data exploitation in different systems. As an example, installation of a simple data transfer component in the main server was performed in order to push received village school data in real-time to the Schneider ecoStruxure EnMS system. Status of each village school can be included in the ready user interface, which the municipality janitors use in the daily work.

4.1.5. Investments timeline

- Procurement*: from 01/03/2018 to 30/09/2019:*

First procurement concentrated in temporary reference and diagnostic measurements. For that purposes, versatile energy consumption measurement system with easy non-intrusive installation was in target. The tendering was executed in spring 2018, and the procurements were made in June 2018. The procurement included two Flexim Fluxus F601 energy flow meters and a weather station. This system can measure four individual energy flows at the same time, while the weather station records the outdoor conditions for the measurement period. As the flow sensors are based on ultrasound, all installations are based on clamping on pipes, which makes it also fast to disassembly and move to the next measurement location. Measurements with this system was made in several phases in Sievi municipality during the project.

Second procurement process included two consecutive phases. The first of them was executed during spring 2019, and consisted of the core system selection, and at that time, Beckhoff solution was chosen, and the programming and configuration was started immediately in summer 2019.

The second tendering was arranged around the sensors, converters and other peripherals, which required exact knowledge not only of the core system, but also of pipe diameters and other site-specific details. That part of the procurement was completed in September 2019, after which the physical installation started.

- Installation: *from 01/07/2019 to 31/01/2020:*

Installation duties were shared so, that Centria took care of all programming, configuration, electrical circuits and connections, assembly of devices to the enclosures and final on-site installation and cable attachments. Sievi municipality was responsible of all activities in plumbing and physical pipes as well as providing ethernet connection in the room.

The sensor system is based on Beckhoff CX -series embedded rail PCs connected to the sensor set tailored for each building needs. In most cases, the consumption is measured with using a combination of a flow sensor and temperature sensors for supply and return lines. In two buildings, however, there is a legacy energy meter already, which is read via pulse output. Typical closet energy meter with the power supply, the Beckhoff CX rail PC and converters (left to right in the figure 1.).

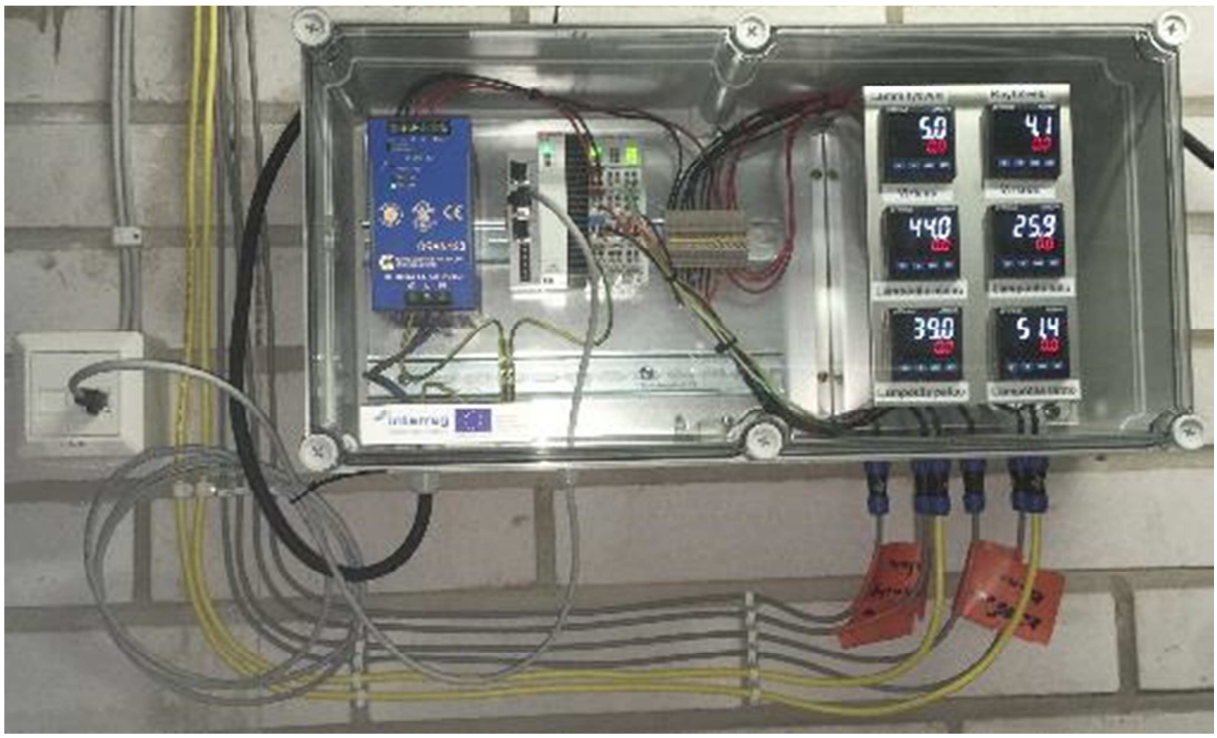


Figure 1. Energy meter with the power supply, the Beckhoff CX rail PC and converters.

- Data collection and Analysis*: from 01/11/2019 to 30.9.2020*

All data is transferred then to the Beckhoff C6015 server to the town hall, which stores the data and shares it for the further registered services and UIs. The needed database and MQTT components were installed and configured. In addition, separate Grafana-based user interface was created for easier perception and clarity. See example in figure 2.

Figure 2. Grafana-based user interface showing data from different village schools.

The provided user interface has easily customizable view on data both as present snapshot and as historical trends. That way, certain incidents in the use of buildings can be analyzed by consumption curve, also malfunctioning and problems are easy to detect and analyze.

4.1.6. Beneficiaries and benefits

The main beneficiary in this investment was Ylivieska region. In portable energy monitoring system, the set of devices are used in regional level. For village school investments, Sievi municipality acts as a reference location within the region and thus is the main beneficiary. The main target group is the technical administration of Sievi municipality, and building unit in particular. With this investment, they can now have access to the real-time consumption data of all school buildings, which helps significantly not only daily maintenance and monitoring, but also keeps administration better on track of the consumption status of each building.

All this enables better awareness, which can be further channelled to building users in order to affect to their behaviour.

4.1.7. Description of the implemented technology/solution/software within the investment(s)

The total set of main components of the investment is as follows:

- Portable energy monitoring system for making temporary diagnostic measurements in municipalities, including:

- 2 x Flexim Fluxus F601 flow meters with a needed set of clamp sensorsa and accessories, see https://www.flexim.com/us/products/portable-flowmeters-liquids/fluxus-f601
- MaxiMet GMX500 weather station, see http://www.gillinstruments.com/data/datasheets/1957-008%20Maximet-gmx500%20Iss%207.pdf

- Village school installations for 6 village schools of Sievi municipality

- Beckhoff core system, including:
  - 1 x C6015-0010 Ultra compact control cabinet PC with needed licenses (server);
  - 6 x CX8190 DIN rail industrial PCs with the needed SW licenses (school PCs);
  - 4 x EL3068 8ch analog input terminals 0…10V (flow metering schools);
  - 2 x EL3064 4ch analog input terminals 0…10V (schools with ready energy meters);
  - 6 x EL1002 2ch digital input terminals 24V (digital i/o to every school for UPS control etc.).

- Peripherals, including:
  - 5 x Vortex flow meters for different pipe diameters (DN25,32,50,65);
  - 10 x PT100 surface temperature sensors;
  - 15 x ATR243-20 converters;
  - Needed cables, enclosures and small consumables.

4.1.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

The connection to the CBS is twofold. Firstly, the portable energy measurement system contributes to the capacity building by providing valuable data from the shadowed heating system segments. With all provided parallel measurements, heating, ventilation and hot tap water usage curves can be recorded simultaneously in the same building. Analysis of that data can reveal not only valve oscillations and other hidden problems in the heating system, but also provides data of building user behavior, possibly consumption share between different sections of the building.

All this was taken into account in the training plan of Sievi, and several exemplary measurement campaigns were executed for supporting the plan. Moreover, same practice can easily be applied also for other municipalities in the region. Every municipality has problematic buildings, which have hidden characteristics that can affect strongly to the overall consumption, if not handled properly.

As Sievi municipality is not a direct project partner, its responsibilities for political processes to promote EnMS-related further actions and investments were rather limited. *ActNow!*, however, was able to create important enhancement in competence of administration regarding building energy consumption.

4.1.9. Identified obstacle and barriers

As said before, the main barrier for further actions was the absence of Sievi municipality in the project in official manner. It was selected to reference location of Ylivieska region based on the expressed willingness, but the relationship has been in practical level solely with administrational staff of technological unit of the municipality. Their mandate is limited for further actions.

Another barrier came from monitoring system company service. During earlier years, Sievi municipality has made rather comprehensive contracts with Schneider to provide services and cloud-based monitoring systems for their building automation systems in major municipal buildings. As typical, this kind of services are based on monthly fees based on agreed subscriptions. Therefore, procurement process for the EnMS service was not applicable. Instead, it requires administrational and partly political decisions, which are financed by the municipality itself and which thus have far-reaching effect for budgets and municipal cost structure for further years.

4.2. Elva (Estonia)

Energy consumption and indoor climate monitoring system for public buildings

Estonian partners have chosen a strategy, where they select a collection of essential pilot buildings in order to equip them with real-time monitoring of energy consumption. The idea is to design this monitoring solution carefully so, that this monitoring system can be scaled up later on to other municipal buildings in Elva after the project. That way the municipality earns the most tangible benefit for their building management in the future.

Elva municipality plans to use the project EnMS to store the information.

4.2.1. Summary of the pilot investment

Partners/Beneficiary involved: Elva Rural Municipality, LETEK

Name of Pilot Testing Measure: Energy consumption and indoor climate monitoring system for public buildings

Location of Pilot Testing Measure:

- Konguta Basic School - Annikoru tee 7, Annikoru village, Elva Rural Municipality, Tartu County 61202
- Elva Basic School – Tartu maantee 3, Elva, 61504 Tartu County
- Elva Gymnasium - Puiestee 2, Elva, 61503 Tartu maakondCount
- Elva Rural Municipality Centre - Kesk 32, Elva , 61507 Tartu County
- Elva Murumuna Kindergarten - Kesk 29 , Elva, 61507 Tartu County

Owner of the investment: Elva Rural Municipality

Coaching partner: LETEK

4.2.2. Background

Elva district heating system including distribution network had been renovated and modernized. Number of blocks of flats had undergone complete renovation, including energy saving measures, reconstruction of heating system, installation of ventilation system etc. The initiative came from the housing associations and the municipal real estate management company Varahalduse Ltd. Supporting funding had been applied for from the Environmental Investment Centre and dedicated financing institution Kredex. Satisfaction of inhabitants of renovated buildings has been the best motivator for other houses to follow their example. In addition to visual effect and 50-60% reduced energy consumption, people enjoy considerable decrease of monthly expenses on heating.

Public buildings had been renovated as well, most recently kindergartens and a high school. But there was no energy managing system developed.

4.2.3. Main problem to be addressed

As the project plan describes, “investments in Computer Aided Energy Monitoring Tools have been carried out during the project which allow an energy monitoring in due time and make energy management much easier.” This gives an accurate reference for reflecting the investment plans to the project intentions. The idea of the investment is not increasing the energy efficiency of the municipality directly, but to provide better technological tools to make it as an internal process of the municipality itself. Therefore, the added value comes by the more efficient building management and maintenance processes with accurate real-time awareness of the situation. This leads to the more far-reaching benefits than classical energy investment as such.

Investment process is part of GoA 3.2, and to promote it, the dedicated investment workshop was organized as a part of the consortium meeting in Gdynia in October 2018. During that workshop, the basic guidelines for the investment process were presented and the fundamental approach of partners was discussed.

As there was no energy management system in the municipality, it had to be developed. The main challenge was to achieve common understanding of the importance of energy management and wider use of renewable energy sources, provide necessary awareness rising and cover the knowledge gap.

4.2.4. Aim and scope of the pilot investment

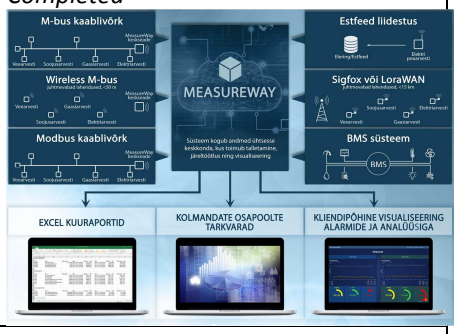
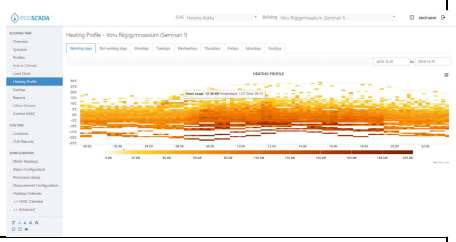
The main goal of the planned pilot investment was to develop and install an energy consumption and indoor climate monitoring system for publicly-owned buildings.

The selected system has not been tested/implemented in this manner in local governments before. The technology used is innovative as well, as the monitoring system shall use a LoRa network deployed in Estonia for communications.

4.2.5. Investments timeline

The investment included several steps that were executed according to specific timeline. The timeframes of the investment phases and the description of measures in Elva municipality is given in table 1

Table 1. Timeframe and description of energy efficiency measures in Elva municipality.

Phase	Timeframe	Measure	Description	Status
1	*20.10.2018-01.02.2019*	*Launching the investment preparation process*	• *Energy Efficiency Group established with stakeholders* • *Overview of municipality-owned real estate objects* • *Technical audit of the buildings to establish the baseline* • *Technical audit to determine the optimal type and number of parameters that would be needed for energy efficiency measures*	*Completed*
2	*01.03.2019-16.08.2019*	*Procurement phase*	• *Technical annex developed based on the information from the Energy Efficiency Group* • *Consultations with various sensor and communication technology providers* • *Procurement carried out*	*Completed*
3	*23.09.2019-4.10.2019*	*Installation*	• *Procurement and ordering of additional sensors* • *Installation of heat and electricity meters* • *Configuring the web platform* • *Installation of indoor climate sensors*	*Completed* 
4	*7.10.2019-*	*Data collection*	*Some new types of data are being recorded for the moment until the web platform is set up*	*Completed* 
5	*1.11.2019-30.04.2020*	*Data processing/analysis System optimization*	*The web platform for data visualisation and analysis is online*	*Completed*

4.2.6. Beneficiaries and benefits

Wide spectrum of stakeholders are involved locally including public utilities, energy system operators, NGOs, housing companies, public administration, energy auditors and local government council members. The target groups of the project are primarily municipality staff members engaged with property management. They should be encouraged to implement and further develop their existing strategies target-oriented and especially under the scope of energy efficiency in buildings.

It is expected that the coverage of the EnMS shall be extended and that the work shall result in actual energy efficiency measures that are taken. The municipality has already invested in internal reorganization to centralize building management. The Municipality is also seeking to invest in energy efficiency measures once they are proposed.

Step-by-step it was expected to reach a kind of standard solution which we will implement (all buildings will be included in Archibus, all data will be visible in Ecoscada) in the whole municipality - like standard meters in different rooms, at different consumers, all following the same system and standard, working in the same environment and producing comparable data.

After the system is installed it will help a newly-created local government department to understand better how their buildings function, how and if the designed HVAC system provides the indoor climate that is required by law in the buildings that they manage (schools, kindergartens, administrative buildings etc).

4.2.7. Description of the implemented technology/solution/software within the investment(s)

LoRa WAN and SIgfox based wireless sensors were purchased that connect to the back-end of our service provider. Data is then visualized on Ecoscada platform that allows setting alarms and viewing historic data, as well as comparing data for the same period in year x, x-1 and x-2 (see figure 3).

Data collected is:

- Main meter data for heat and electricity,
- 15 indoor climate sensors in 5 buildings measuring/recording
    - CO_2 levels,
    - Humidity,
    - Temperature.

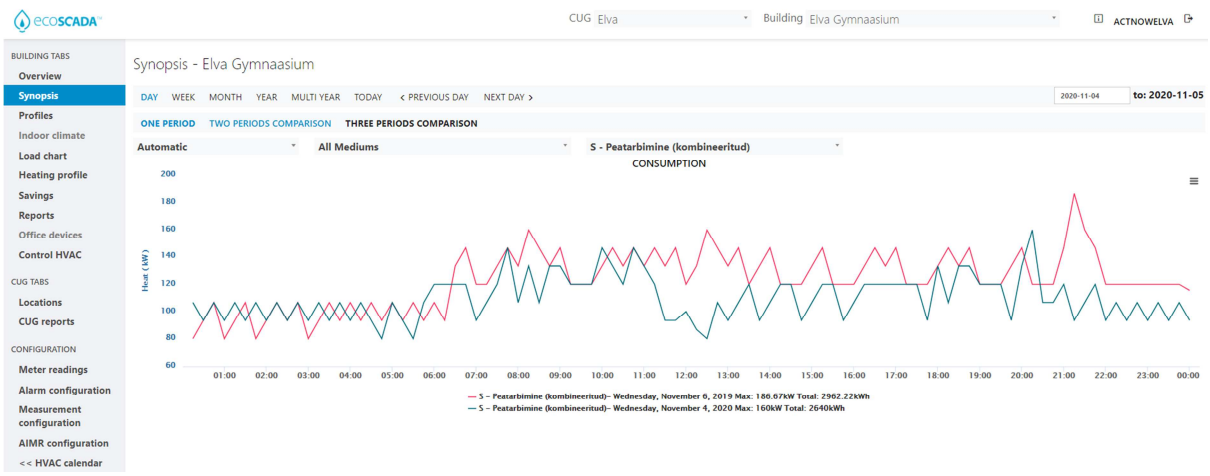


Figure 3. Data visualization on Ecoscada platform.

Data is then entered to Archibus, which also stores floor plans and data about the equipment in the building. In this way managers are able to compare buildings, sites and their energy performance. Archibus allows to include buildings that do not have remote reading capabilities yet and data is entered manually (see figure 4). Archibus also allows normalization of Heat Degree Days parameter, which means that year-on-year comparisons are possible, enabling the municipality to assess trends on energy performance through time.

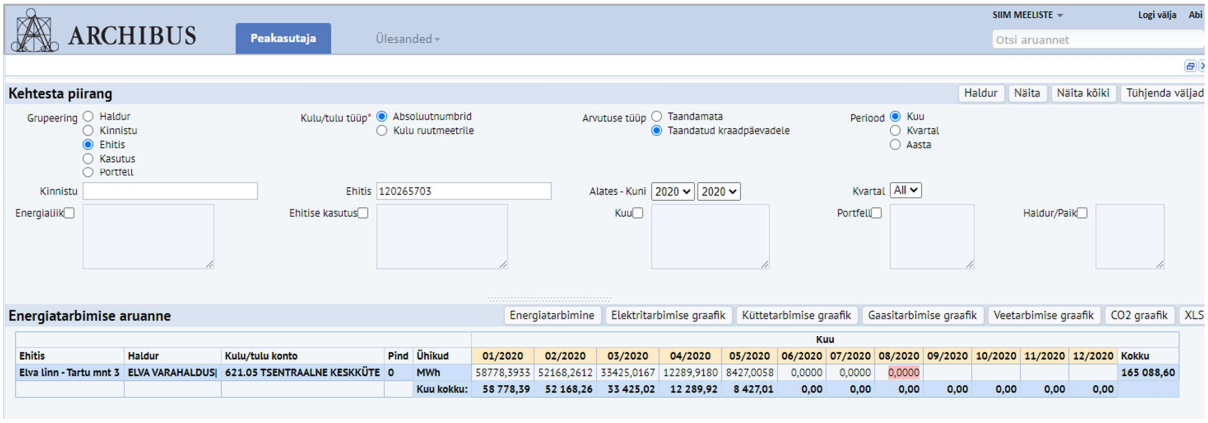


Figure 4. Data proccessing in Archibus platform.

All investments have a direct connection with the EnMS as they shall in one way or another enable near-real-time data collection and facilitate energy-related data processing. The sensor network provides metering data and the software platforms enable to work with that data, to visualize it and to incorporate this into everyday work and implementing an EnMS in Elva Municipality.

4.2.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

All the investments shall make up a tool that is used for teaching and learning about energy management through practical implementation. Recording and visualizing energy management data is the first step to

have policymakers think about energy efficiency measures and operating with real data shall give a good basis to develop well-analyzed energy efficiency measures. The investments made during the project work as an enabling tool for other linked investments planned in the local development plan of the energy.

All training events followed the logics of project/investments development and selected topics supported capacity building and knowledge update to prepare the next stage of activities.

During the project a modified development strategy for 2019-2025 for the municipality was developed (yet to be officially voted on by the council) where efficient management is set as a separate target that includes sub-activities as “energy efficient operation of boilerhouses”, “increased energy efficiency of buildings and increased use of alternative energy sources” and “operation of publicly-owned buildings and facilities with energy efficiency as the guiding principle”. The draft proposal is available here:

https://www.elva.ee/documents/17608326/17943776/Lisa+1.+Elva+valla+arengukava+ja+eelarvestrateegia+%28fin%29.pdf/1cd6628d-5ff5-473c-b616-17e5786a6f6c

4.2.9. Identified obstacle and barriers

The main obstacle has been lack of capacity and professional knowledge in local municipalities, which can be improved by respective training programs and cooperation with more advanced municipalities.

4.3. Gulbene (Latvia)

Heating consumption monitoring system in several municipal buildings

In Latvia, about the half of the 90 municipal buildings are still missing accurate energy consumption metering. The investment strategy is based on lifting up these buildings to the new level in energy monitoring.

In practice, this means in particular the installation of heating meters to the buildings, not just meters for calculating fuel consumption etc.

This information is stored to the EnMS together with electrical and water consumption data for assisting the municipality in decision-making.

4.3.1. Summary of the pilot investments

Partners/Beneficiary involved: Gulbene Municipality

Name of Pilot Testing Measure: Implementation of heating energy meters and remote data reading systems in whole Gulbene municipality buildings

Location of Pilot Testing Measure: Gulbene Municipality

Owner of the investment: Gulbene Municipality

Coaching partner: Riga Technical University

4.3.2. Background

The real implementation of the capacity building schemes (CBS) in the participating municipalities made by the LEEGs (acting as steering bodies for future energy efficiency measures and definition on-the-job-training) is providing the ground to provide an accurate reference for reflecting the investment plans to the project intentions.

The idea of the investment is not increasing the energy efficiency of the municipality directly, but to provide better technological tools to make it as an internal process of the municipality itself. Therefore, the added value comes by the more efficient building management and maintenance processes with accurate real-time awareness of the situation. This leads to the more far-reaching benefits than classical energy investment as such. Energy manager can analyze collected data from installed remote data collection system and develop action plan for energy efficiency increase in buildings.

Prior to the *ActNow!* project, energy management in Gulbene municipality was limited to an excel table on electricity and heat consumption of Gulbene town buildings. Remote reading devices were installed in Gulbene town buildings for almost all buildings, but the retrieved data was not used. There were no heating meters in parishes.

There was no Energy Manager in Municipality and no SECAP.

4.3.3. Main problem to be addressed

There are close to 100 municipal buildings in Gulbene municipality (schools, kindergartens, administrative buildings, museums, libraries etc.). The dominant share of municipal buildings (around 90%) heat get from district heating, some building has own heat producing unit. Based on the performed inventory half of buildings have heat meters, but other half building doesn't have any heat metering equipment. For many buildings the heat consumption is calculated based on the used fuel amount in boiler houses. Also, there is no fuel consumption data in some district heating systems. Therefore, accuracy of data about heat consumption is not enough to make deep data analysis and develop energy efficiency plan at municipality.

Within the project, Gulbene municipality understood that it was necessary to plan energy efficiency measures in order to achieve better indicators. However, this requires qualitative data and analysis. Therefore, investments were made in obtaining high-quality heat energy data, as well as in the analysis of electricity and heat energy data. LEEG was created and SECAP was developed to plan the works.

As the project plan describes, "investments in Computer Aided Energy Monitoring Tools have been carried out during the project which allow an energy monitoring in due time and make energy management much easier." This gives an accurate reference for reflecting the investment plans to the project intentions. Investment process is part of GoA 3.2, and to promote it, the dedicated investment workshop was

organized as a part of the consortium meeting in Gdynia in October 2018. During that workshop, the basic guidelines for the investment process were presented and the fundamental approach was discussed among partners and approved.

4.3.4. Aim and scope of the pilot investment

Heating energy meters and remote data reading systems were implemented in whole Gulbene municipality buildings that are connected with district heating systems. Additionally, data analysing system was implemented, where data from remote data collection system have been uploaded for analysis. Data analysing system provides analysed data to Energy Manager and building management staff. This will help to improve energy efficiency. The personal involved in Energy Management knows what to do if analysed data shows low energy efficiency.

Small remote data collection system was at Gulbene municipality before project implementation and consisted of 5 buildings. The technical solution used approved optimal balance between cost and quality. Therefore, purchased equipment is based on a similar technical solution and supplemented the existing remote data reading system.

Energy management system is something new in Gulbene municipality. This system has been developed specifically for the particular case.

4.3.5. Investments timeline

The investment included several steps that were executed according to specific timeline. The timeframes of the investment phases and the description of measures in Gulbene municipality is given in table 2.

Table 2. Timeframe and description of energy efficiency measures in Gulbene municipality.

Phase	Timeframe	Measure	Description	Status
1	11.07.2018 to 16.10.2018	Reason(s) for the selection of a specific investment/ Identification of gaps-needs	Discussion with the expert partner on need to implement the energy management system and the relevant activieties. The municipality clarified the current situation and the availability of heat and electricity data. During the research it was found out that heat in district heating systems in several parishes is not recorded by heat meters. High-quality thermal data analysis requires accurate heating energy consumption data of each building. Therefore, it was decided to install heat meters with remote data collecting systems in buildings where there are no such meters.	Completed
2	18.03.2019 to 25.04.2019	Procurement phase	Before the formal procurement procedure, together with the RTU procurement subject specifications were developed. Requirements for circuit diagrams for heat meters and accessories, as well as parameters for remote data reading system were defined. The Procurement Specialists prepared the Procurement Regulations and the necessary additional requirements for the tenderers in order to avoid purchasing poor quality products and receiving poor quality services. The official procurement procedure was announced on 18.03.2019, when the documentation was placed in the	Completed

			Electronic procurement system and the Procurement Monitoring Bureau had accepted the documentation. After the deadline for submission of tenders, the compliance of the tenders with the regulations and the qualification of the tenderers with the requirement was evaluated. On 25.04.2019 The Procurement Commission decided to conclude contracts with two bidders. Rubate Ltd. Installed heat meters and remote data reading systems weree installed by Metlink Ltd.	
3	15.05.2019 to 30.08.2019	Installation	Contracts were signed on 13.05.2019 with Rubate Ltd. and 15.05.2019 with Metlink Ltd. Rubate Ltd. installed heat meters from 13.05.2019 to 27.07.2019. Meters and all necessary additional fixtures, to ensure the quality of the equipment, were installed in 39 objects. Metlink Ltd. installed remote data readers from 15.05.2019 to 30.08.2019. The equipment is connected to heat meters. A total of 82 heat meters are read remotely. Data accumulates on the server and the platform displays graphs and provides export capabilities.	Completed
4	01.10.2019 to 01.06.2020	Data collection	Some buildings are already consuming heat, but the heating season could start in early October, so the period is scheduled from 01.10.2019. The data are stored on the server. The system reads the heat meters once per 20 minutes. Further preparing this data for download. If necessary, the platform also provides visualization of their graphs. The data have been collected for one complete heating season.	Completed
5	24.04.2020 to 08.05.2020	Procurement phase	Before the formal procurement procedure, together with RTU procurement subject specification was developed. We defined the requirements for visualizations, data entry procedures and program design. Employee connectivity and activity levels were also defined. The Procurement Specialists prepared the Procurement Regulations and the necessary additional requirements for the tenderers in order to avoid purchasing poor quality products and receiving poor quality services. The official procurement procedure was announced on 24.04.2020, when the documentation was placed in the Electronic procurement system and the Procurement Monitoring Bureau had accepted the documentation. After the deadline for submission of tenders, the compliance of the tenders with the regulations and the qualification of the tenderers with the requirement was evaluated. 03.06.2020 The Procurement Commission decided to conclude contracts with ABC Idea Ltd.	Completed
6	11.06.2020 to 02.09.2020	Installation	Contracts were signed on 11.06.2020 with ABC Idea Ltd. The contractor developed the system architecture and the basic version, which was further discussed with the Municipality. During the evaluation and contacting the maintenance provider of the electricity supply system JSC Sadales tīkls, we concluded that they are not yet ready to automatically integrate data into such systems. They promise to start at the end of this year. 21 objects have been added to the system. For which the last	Completed

			five years of heat and electricity data have been entered into the system and the current situation is read automatically from the previously installed remote monitoring system for heat. The system offers the possibility to view heat and electricity data in different sections, including per 1 square meter of the building, as well as it is easy to compare and disconnect the connected objects. The system automatically sends reports to the specified emails to inform employees.	
7	02.09.2020 till today	Data collection and analysis	Currently, the system is being adapted for each user, registering them and indicating the objects under their responsibility. Employees were informed about the operation of the system and trained to use it. The system receives the information automatically or it can be imported directly from the system to the system in excel format.	In progress

4.3.6. Beneficiaries and benefits

The energy management system requires accurate consumption data, as well as a large part of district heating systems in the parishes requires heat metering in apartment buildings and municipal facilities. Remote data reading allows municipality to prevent unexpected problems in a timely manner, as well as to determine the highs and lows of heat capacity, as well check boiler efficiency and fuel compliance. Energy management system gives benefits for everyone in Municipality, because the whole system will work on energy efficiency and to keep good indoor climate conditions. The staff will receive analysed data that will allow them to understand the relationship between energy consumption and financial resources. Energy efficiency increase will provide opportunity decrease heating costs.

The implemented system is expected to continue to operate after the end of the project. There are planned funds from the municipal budget to finance the operation and maintenance of the system. Also, there is planned to add new buildings to the system, because currently only Gulbene municipality buildings in Gulbene town and street lighting will be added. At the end in the system need to be all Municipality owned buildings, street lightning and car park.

The energy management program also calculates CO_2 emissions based on the energy consumption. As a result, more efficient use of energy also provide opportunity reduce CO_2 emissions. Additionally, the Municipality is already investing in the installation of the high energy-efficient boiler for heat production, that also allows reduce fuel consumption and produced CO_2 emissions.

4.3.7. Description of the implemented technology/solution/software within the investment(s)

The remote reading system Metlink is connected to a heat meter and sends the data to the cloud, where the data is then structured and displayed on the webpage interface. There is module placed in the heatmeter which transfers information to Met box. Further, Met box transfers information with GSM to the cloud (see figure 5).

Figure

5. Principal sheme of used remote data collection system.

Based on the received data, it is possible to ensure the operation of the building's automatic control system, which will promote the increase of the building's energy efficiency indicators. Data can also be exported for deap analysis later. Example of data collected is shown in figure 6.

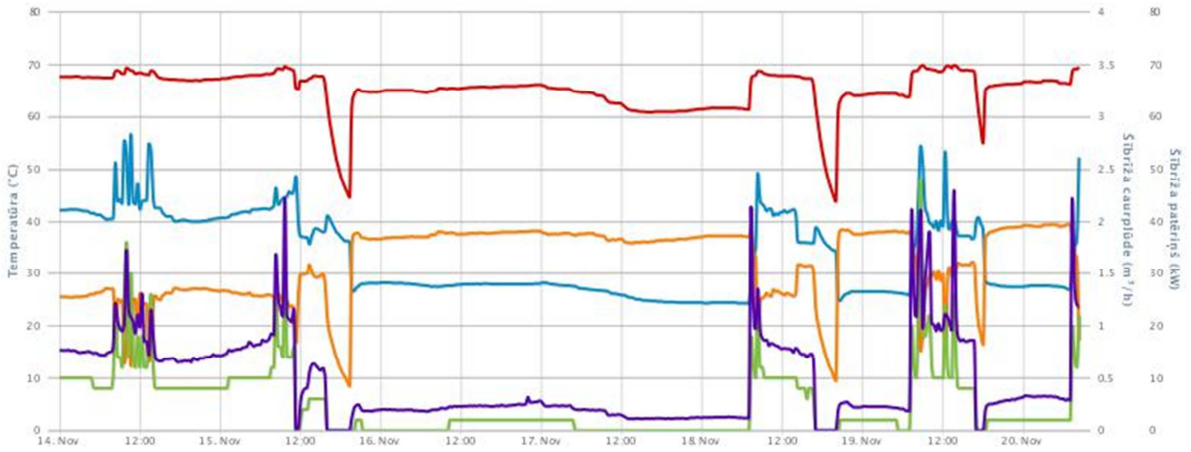


Figure 6. Example of data collected data visualization system.

The energy management system receives data from the remote reading and collection system, as well as imports data from other data collection systems available on the municipality for further analysis. The scheme of energy management system is shown in figure 7.

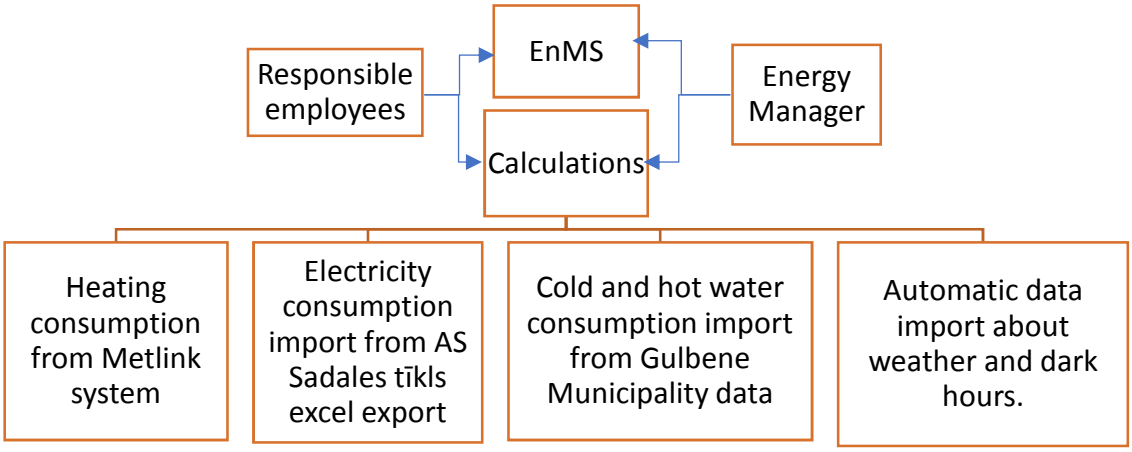


Figure 7. Principal sheme of energy management system

The energy management system reflects the data by group. This makes it easy to compare the collected data, draw conclusions and develop action plan for energy efficiency increase. The data comparison in municipality is made in specific user interface, where data is presented in form of graphs (see figures 8 and 9).

Figure 8. Example 1 of data comparison in energy management system user interface.

Figure 9. Example 2 of data comparison in energy management system user interface.

4.3.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

According to the state-of-the-art assessment of the Energy management and energy strategies for *ActNow!* the following main problems were identified in parishes where energy data and heat metering equipment was lacking before implementation of the project. For Energy management system in Gulbene Municipality there was a high need for initial data about heat consumption to make deep analysis and develop action plan. Building Managers need to know what is happening in their building, therefore all buildings and street lightning will be connected to the system making a unique system for data analysis.

First and second workshops were focused on the EnMS and SECAP development, as well as data collection for SECAP.

Understanding the needs of local stakeholders and politicians for better synergy on EE improvements for SEAP Capacity building action was set in the CBS. The municipality currently is in the process of developing SECAP, in which stakeholders participate and discussion happens.

At the same time there are set separate training workshops for employees of the Municipality about SECAP, EnMS and EE issues.

Politically, the decision was made when the council decided to participate in the *ActNow!* project. Till now there were only some political decisions taken. Second political decision was to make official LEEG. Third decision was accepting Gulbene district development program for 2018-2024, where some of the main goals in energy efficiency were set, for example, develop SECAP and EnMS in Municipality, energy certification for buildings, evaluation of heating and street lighting systems, etc.

4.3.9. Identified obstacle and barriers

Some difficult situations arose directly from the technical installation of the equipment. The heat meter does not have enough space to run it or there is groundwater in the basement of the building that needs to be taken out. Municipality had to think of ways to redesign it to make heat meter work properly. Another problem was the independent signalling of the remote data reading system at locations in the basement with historic masonry walls and at places where power cannot be provided. The supplier had to think of additional solutions to secure the data transfer. The signal was amplified using antennas.

When implementing an energy management system, the challenge is to encourage those who are responsible for energy management in buildings, educate them so that they understand its operation and the results of data analysis. Municipality is currently providing various workshops to inform and educate employees about energy efficiency issues.

4.4. Silute (Lithuania)

Smart metering systems in 10 municipal buildings

The investment process in Silute has shown the considerable needs in many levels of the system. There is a group of recently renovated buildings with modern building automation. On the other hand, there are many buildings without the needed quality of HVAC systems to allow accurate energy monitoring. Half of the municipal buildings don't have any energy metering, and the management structure of buildings doesn't support the needed commitment.

As a solution, the 10 buildings with major needs have been selected, and equipping most of them with energy monitoring system was the main priority.

4.4.1. Summary of the pilot investments

Partners/Beneficiary involved:

- Silute heating network;
- Hugo Scheu Museum building complex;
- F. Bajoraitis Public Library;
- Kindergarten "Pušelė";
- Kindergarten "Žvaigždutė";
- Kindergarten "Žibutė";

Name of Pilot Testing Measure: Hardware adaptation and purchase of hardware + software for energy monitoring system

Location of Pilot Testing Measure:

- Hugo Scheu Museum building complex - Lietuvininkų g. 4, Šilutė 99185
- F. Bajoraitis Public Library - Tilžės g. 10, LT-99172, Šilutė
- Kindergarten "Pušelė" - Miško g. 8, Šilutė 99148
- Kindergarten "Žvaigždutė" - V. Kudirkos g. 20, Šilutė 99121
- Kindergarten "Žibutė" - Cintjoniškių g. 3, Šilutė 99128

Owner of the investment: Administration of Silute District Municipality

Coaching partner: Civitta

4.4.2. Background

The real implementation of the capacity building schemes (CBS) in the participating municipalities made by the LEEGs is providing the ground for an accurate reference when reflecting the investment plans according to the project intentions.

The idea of the investment is not increasing the energy efficiency of the municipality directly, but to provide better technological tools to make it as an internal process of the municipality itself. Therefore, the added value comes from more efficient building management and maintenance processes with accurate real-time awareness of the situation. This leads to the more far-reaching benefits than classical energy investment as such.

There was lack of data and analysis of data on energy consumption in the Municipality. Main identified problems with collecting data: wrongly collected data (human factor), lack of human resources and there was no way to monitor real-time energy consumption in municipal buildings and in street lightning. Collected data was not analyzed, and since data is collected only on a monthly basis, it was not possible to evaluate critical points or typical situations.

4.4.3. Main problem to be addressed

As the project plan describes, “investments in Computer Aided Energy Monitoring Tools have been carried out during the project which allow an energy monitoring in due time and make energy management much easier.” This gives an accurate reference for reflecting the investment plans to the project intentions. The idea of the investment is not increasing the energy efficiency of the municipality directly, but to provide better technological tools to make it as an internal process of the municipality itself. Therefore, the added value lies in more efficient building management and maintenance processes with accurate real-time awareness of the situation. This leads to a more far-reaching benefits than classical energy investment as such. Investment process is part of GoA 3.2, and to promote it, the dedicated investment workshop was organized as a part of the consortium meeting in Gdynia in October 2018. During that workshop, the basic guidelines for the investment process were presented and the fundamental approach of partners was discussed. The approach included such actions:

- Identification the most important aspects that affect energy efficiency by carrying out regular analysis;
- Use energy consumption monitoring data for derival of current energy performance indicators, analyzing them and comparing against major energy performance indicators.
- Monitoring energy consumption on a regular basis.
- Carrying out energy consumption analysis, review current situation and set targets.

4.4.4. Aim and scope of the pilot investment

The aim of the investment was to have hardware adaptation by the purchase of hardware and software for energy monitoring system (i.e. automation of heat stations and smart metering installation in 5 public buildings).

In the beginning of 2017 smart heat consumption management system was installed into 3 public schools. The results were good (decrease in heat consumption 7-20 %), therefore, the Municipality decided to proceed with such measures.

4.4.5. Investments timeline

The investment included several steps that were executed according to specific timeline. The timeframes of the investment phases and the description of measures in Silute municipality is given in table 3.

Table 3. Timeframe and description of energy efficiency measures in Silute municipality.

Phase	Timeframe	Measure	Description	Status / problems
1	01/04/2018 to 31/03/2019	Identification of gaps-needs In-depth analysis of Municipality buildings	In-depth analysis of Municipal buildings was done in order to assess in which buildings it would be the most effective to install smart metering system. That included: - Analysis of possible monitoring tools for energy consumption and IT based energy management systems. - Building assessment and collection of necessary data from public enterprises and energy suppliers. - Preparing and analyzing the list of potential municipal buildings for installing energy management system; - Organizing visits to shortlisted (for investment) buildings to identify what exactly needs to be done in each of them.	Completed 14 from 47 municipal buildings (mostly schools and kindergartens) were shortlisted according evaluation of data, which allows determining which buildings should be most optimal for implementation of heat energy management system (smart metering and energy management included). Obstacles: - There were only 8 municipal buildings with automated heat substations (EnnMS can be installed without additional equipment). - The priority was given to kindergartens and those are buildings without automated heat substations, therefore, bigger investments required. Kindergartens were prioritized due to the fact that the heating in these institutions had to

				be monitored regularly to keep it stable due to weak immune system of the children and their illnesses during the heating season.
2	01/04/2019 to 04/07/2019	Procurement phase	Procurement for automatization of heat stations and smart metering installation in 5 public buildings (including gathering, analysingexamples and preparing suitable documentation for investment (technical specifications, technical projects, public procurement terms and etc..)).	Completed
3	04/07/2019 to 30/09/2019	Installation	Automatization of heat stations in: nursery “Pusele”, nursery “Zibute”, nursery “Zvaigzdute” and smart metering installation in nursery “Pusele”, nursery “Zibute”, nursery “Zvaigzdute”, Hugo Scheu museum, F. Bajoraitis public library.	Completed
4	October 2019 to April/May 2020	Data collection	Daily heat energy consumption, air temperature inside/outside/various places of the buildings	Completed
5	April/May 2020 to August/September 2020	Data processing/analysis System optimization	Data from years 2016, 2017, 2018 was collected and compared	Completed

4.4.6. Beneficiaries and benefits

Beneficiaries: Administration of Silute District Municipality, users of buildings, citizens.

Benefits:

- Decrease in heat consumption – lower costs;
- Less heat energy wasted and decrease of CO_2 emissions;
- Meeting hygiene standards in buildings – better work quality;
- Healthier environment to the children and workers of the institutions.

Administration will maintain further procedures regarding funding for management and monitoring of smart metering system.

4.4.7. Description of the implemented technology/solution/software within the investment(s)

In order to monitor, understand and manage tendencies of temperature changes in the whole building, at least 4 units had to be installed in it. Temperature sensors located in different essential places of a public facility.

Information from temperature sensors is collected by radio. Temperature sensors are powered by an internal (integrated) power supply (battery or accumulator):

- Radio communication frequency - 868 MHz;
- Temperature sensor supply voltage from 1 to 3 V.

The investment is directly related to the EnMS, because of structured annual assessments and energy reports. The example of data collected with help of temperature sensors is shown in figure 10.

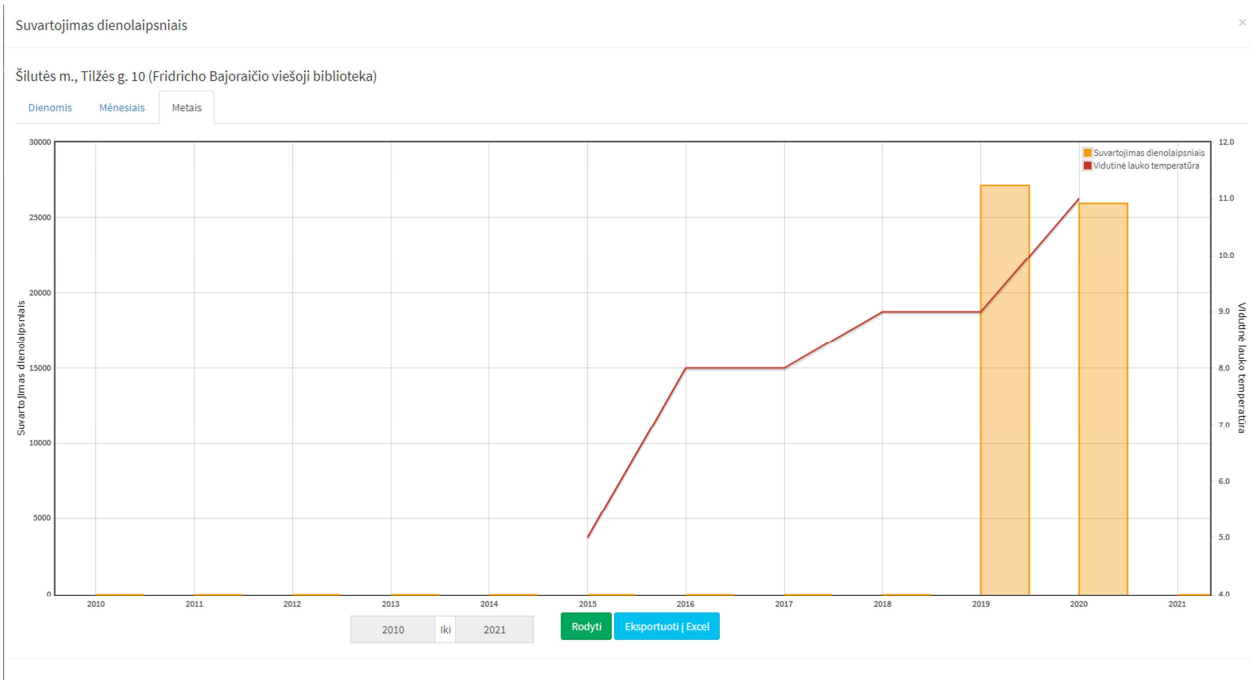


Figure 10. Example 2 of data comparison in energy management system user interface.

4.4.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

In the beginning of 2017 smart heat consumption management system was installed into 3 public schools. The results were good (decrease in heat consumption 7-20%), therefore, the Municipality decided to proceed with such measures. During the *ActNow!* project smart heat consumption management system was installed into 5 more public buildings. Real-time monitoring allows seeing maximum consumption, making comparisons and conclusions about energy losses and ways to save it.

Municipality staff, LEEG members, users of the buildings (and others, interested/involved) were trained on energy saving behaviors, how the system works and etc. Capacity building is being implemented on:

- Energy management systems and data processing, data monitoring, analysis,
- Lithuania's long-term (until 2030) goals in the field of increasing energy efficiency,
- Regulation of increasing energy efficiency in the European Union and Lithuania and the latest changes,
- Energy efficiency measures in the building and transport sectors,
- Lithuania's long-term (until 2050) goals in the field of RES development,
- RES regulation and planning in the European Union and Lithuania and the latest changes,
- RES measures in the building, transport and heat supply sectors,
- European Union initiatives and projects in the field of RES and EE (Covenant of Mayors, ELENA, EUCF and others)

Also, Silute District Municipality decided to renew its SEAP – evaluation of achievements has been made, relevant indicators have been measured and the new SECAP now is being developed. The SECAP will include structured annual assessments and energy reports, self- commitments for energy-saving goals and annual updates of local energy strategies, etc.

The political decision of the town council was made when the application of the project *ActNow!* was submitted. The decision of the director of Administration of Silute district municipality was made in order to have more buildings renovated and get them more energy efficient. Two application forms were submitted to the EEEF and Litgov funds in order to get funding for the preparation of the technical documentation for the renovations of the 37 public buildings. The EEEF application was approved and documentation such as technical projects, investment projects and energy consumption audits are prepared for 11 public buildings. LEEG members in Silute during the implementation of the project *ActNow!* gained more experience in energy management field and made suggestions to the public building renovations, building selections. Also, this made it clear that investment in smart metering system pays off in few years time.

4.4.9. Identified obstacle and barriers

The evaluation for determining which buildings should be most optimal for implementation of heat energy management system (smart metering and energy management included). Within the project, 14 from 47 municipal buildings (mostly schools and kindergartens) were shortlisted according evaluation. Obstacles:

- There were only 8 municipal buildings with automated heat substations (EnMS can be installed without additional equipment).
- The priority was given to kindergartens and those are buildings without automated heat substations, therefore, bigger investments were required.

4.5. Gdynia Municipality (Poland)

New type of system with reading the data from distributor system is installed: direct temperature and air quality control in class-rooms

In Gdynia, the project team is preparing the proposal for purchase - new type of system with reading the data from distributor system. The considerable bottleneck in the process is the municipal budget, which is was finalized in March 2019, after which the procurement process started.

4.5.1. Summary of the pilot investments

Partners/Beneficiary involved: Gdynia Municipality

Name of Pilot Testing Measure: Mobile - air condition dataloggers with monitoring system for selected school building

Location of Pilot Testing Measure: Schools of Gdynia municipality - changed location

Owner of the investment: Gdynia Municipality

Coaching partner: The Szewalski Institute of Fluid-Flow Machinery, Polish Academy of Sciences in Gdańsk (IMP PAN)

4.5.2. Background

The situation prior *ActNow!* action was, and still is, a heritage of the approach to energy management that was present in Poland till the 1980s. It was a result of availability of a very cheap fossil fuel (coal)-based energy. The situation can be summarized by saying that back in those days there was no issue of ecological or economical cost in neither individual, nor urban or municipal design process in Poland.

As most of the municipal buildings are over 30 years old, there are no Energy Management System included in their structure, making it very difficult to improve the energy efficiency or implement any automated energy control system without major construction works. Also, in the field of Computer Aided Energy Monitoring Tool, due to the reasons given above, there are no municipal systems. The current state means a very big demand for systems of this type.

During the building auditing activities, it was found that also the air quality in class-rooms should be controlled and improved. This led Gdynia administration to decision to buy 4 temperature, humidity and CO_2 concentration monitoring systems, which provide administration with online information about the thermal and air conditions in school building. On the other hand, due to limited municipality resources, it was decided that innovative heat control system was build and tested by IMP PAN using their own resources. The conclusion on the heat consumption monitoring were shared with the municipality.

4.5.3. Main problem to be addressed

A crucial first step to be taken in implementing EnMS in the municipality is to build a database of real-life measurements describing the energy consumption of the building(s) under consideration. To do this, a

net of measurement stations capable of reading the energy consumption and transmitting them to a remote storage has to be built. This information will allow to assess the possible ways of increasing energy efficiency of the buildings and estimate the costs of it.

4.5.4. Aim and scope of the pilot investment

Planning to increase the energy efficiency of the municipal buildings, the municipality considered first of all schools, because there the demand for energy (electricity and heat) is greater. During the energy audits in school buildings it was found that the air quality is very low (even 4000 ppm CO_2), therefore Gdynia decided to purchase online system to control air quality in the buildings.

The aim of the system developed in IMP PAN was to develop and implement a solution capable of reading and transmitting to a remote storage information describing energy consumption of the site. The exact goal is automated reading of any kind of heat meter that is present in the building, recoding it to digital form and sending via Internet. The scope of interest covers development of the complete necessary infrastructure 'from scratch'. The system is prepared to work with any heat meter supplied only with power source, internet connection and light source (the light source can be of very poor quality). No specific environmental, light or spatial conditions are required. It can be easily installed in any building.

In order to check the possibility of using the vision system, an on-site inspection was carried out in 20 public buildings in Gdynia – but finally it was decided to check the feasibility in IMP PAN premises. The goal of the work was to find a way and prepare a system for measuring consumption of various forms of energy. The interest included thermal energy, electric energy and chemical energy of the burning gas. To measure various forms of energy various instruments are necessary: heat meter, electricity meter, gas meter. All meters installed in buildings have a display. The idea is not to measure, but simply to read the display of the meter that is precise, cheap and already installed without any additional costs or effort.

As a proof of concept, we decided to build two of prototypes. The first system consisted a very cheap IP camera and wire INTERNET data transfer. The camera takes a photograph of the display and transfers via Internet to a PC, where a dedicated software, based on the systems engineering software LabVIEW, reads the value from the display. For the automated character recognition of the values displayed an application in LabView has been developed. The application is based on the 'LV_ReadLCD' library.

The second system using a very cheap hardware (rPi computer with dedicated camera costs approximately 100 Euro) and building our own OCR software using only free tools and libraries can be considered as innovative.

Also, the approach to acquiring data on energy consumption can be identified as innovative, as we have decided to obtain data from the meter that belongs to the energy provider in a way that does not require taking any form of legal agreement with the provider, as we do not make any physical connection or modification to it.

4.5.5. Investments timeline

Procurement for 4 thermal and air quality control systems:

From 21/10/2019 to 18/11/2019*:* with expert partner help and after consultations with various data loggers providers procurement subject specifications were developed. On 18th November 2019 a contractor was selected.

Installation:

From 05/12/2019 to 17/12/2019: contract was signed on 5th of December 2019 and 4 air condition data loggers with monitoring system were installed on 17th of December 2019 in selected Primary School no. 23 in Gdynia.

Due to the simplicity of the system and installing it in the building, there were no problems in this field.

The 4 chosen recorders were purchased and their installation took place in December 2019. The devices were placed in four classrooms in order to compare the results from differently situated rooms (see figure 11). The recorded data can be transferred to a PC via USB cable or via GSM network for further analysis. The data collected from the devices are automatically transmitted and collected in the so-called "cloud". This cloud supports easy online access to measured data. Thanks to this solution, it is enough to have access to the Internet to view the collected data at any time. Obtained values can be displayed in the form of a table or graph, data and reports can be printed or exported for further processing of spread sheet software.

Figure 11. Example of the devices placed in classrooms.

In relation to IMP PAN, innovative system was developed on the experience of testing the first prototype, where installation and lighting were the main concerns. The initial tests gave us some conclusions concerning possible problems. The main one is the quality of the photographs, especially the light uniformity. If it is not good there are problems with the automated analysis. The data on energy consumption were collected every 10 minutes.

The installation of the current version of the system is still an on-going process. As it is a prototype, we are still learning, gaining experience and doing the necessary adjustments.

The main problem was to supply a secure Internet connection for the system.

Data collection and analysis was performed from 07/01/2020 to 15/11/2020. The software of air condition data loggers provides graphs and visualization of a collected data (remote data preview and storage in the cloud). The intention is to collect data for a half heating season and to continue it after the end of the project.

Within the framework of the investment, measuring devices were provided with a computer system. Primary School No. 23 in Gdynia was chosen as a pilot. Pilot data monitoring includes data on the internal

environmental conditions of the building, i.e. data on temperature, humidity, pressure and CO_2 concentration as shown in figure 12.

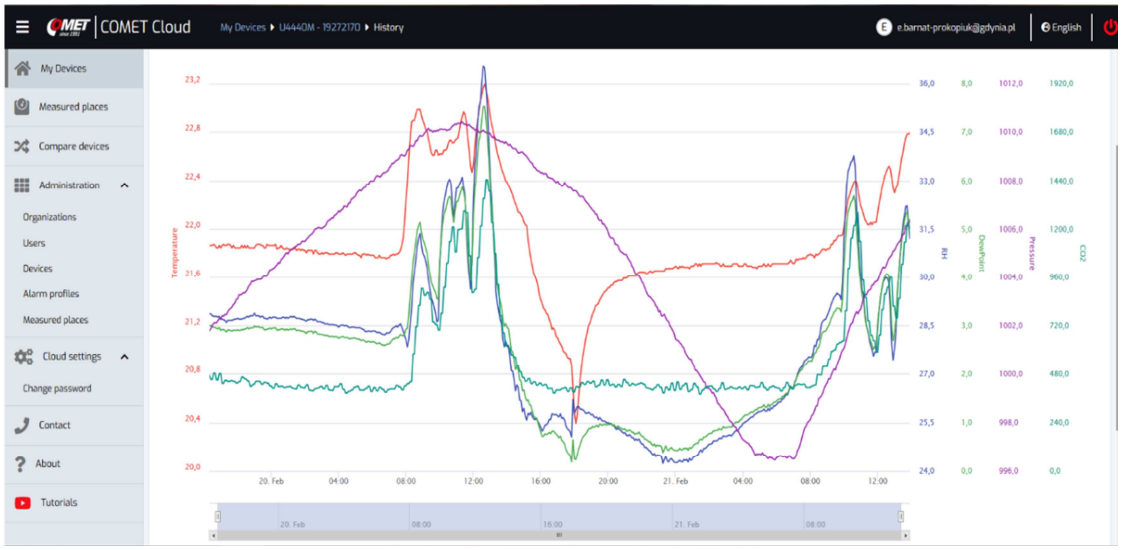


Figure 12. Temperature, pressure, humidity and CO2 concentration in Primary School No. 23 in Gdynia.

The online control of temperature and humidity on 1 November, shown in figure 13, led to following conclusions:

- Lack of heat demand control lead to significant overheating of classrooms even in the time of school lockdown and holidays,
- Too high temperature (above 22°C) decreases pupils concentration,
- During weekends heat supply (temperature) should be reduced significantly through cutting/limiting heat supply,
- The role of online control is evident,
- Too low humidity (below 40%) is not healthy.

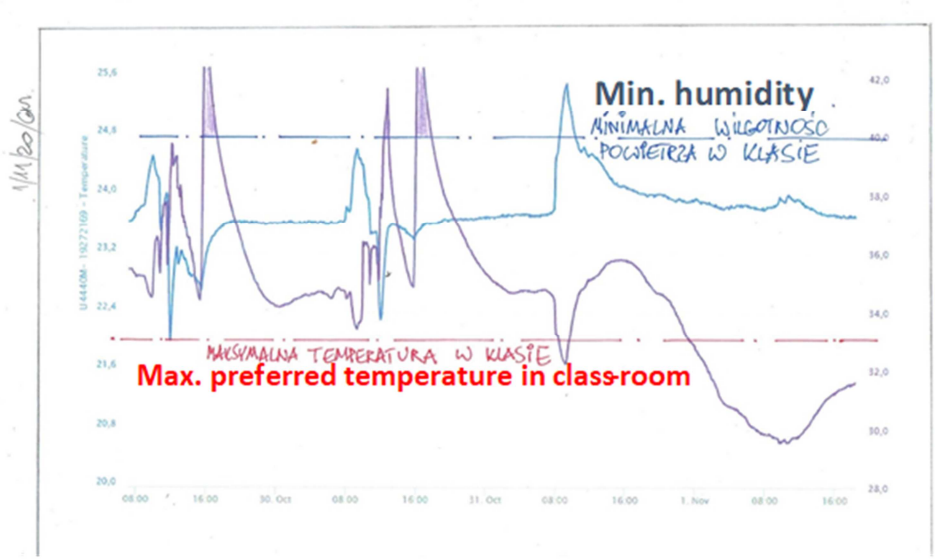


Figure 13. Temperature and humidity on 1 November in Primary School No. 23 in Gdynia.

The data collected in the period of 20.09.2019 – 27.02.2019 in the building of IMP PAN in Gdańsk serves for calculation of the instantaneous and averaged thermal power with resolution determined by meter

quality, shown in figures 14 to 16. Total heat consumption of IMP building in Gdańsk in the period 20.09.2019 – 27.02.2020 is presented in figure 17.

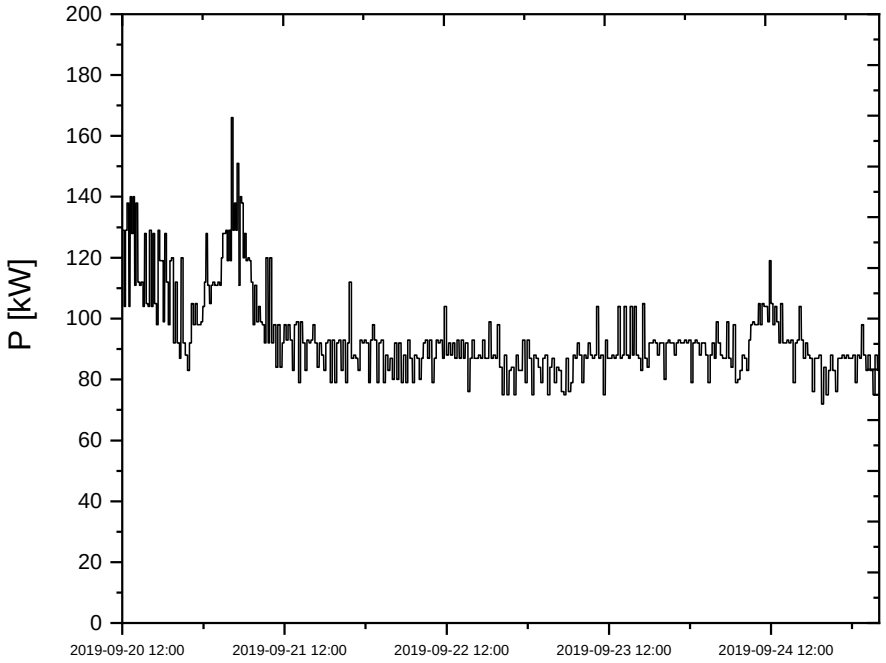


Figure 14. Heat consumption of IMP building in Gdańsk in the period 20.09.2019 – 24.09.2019.

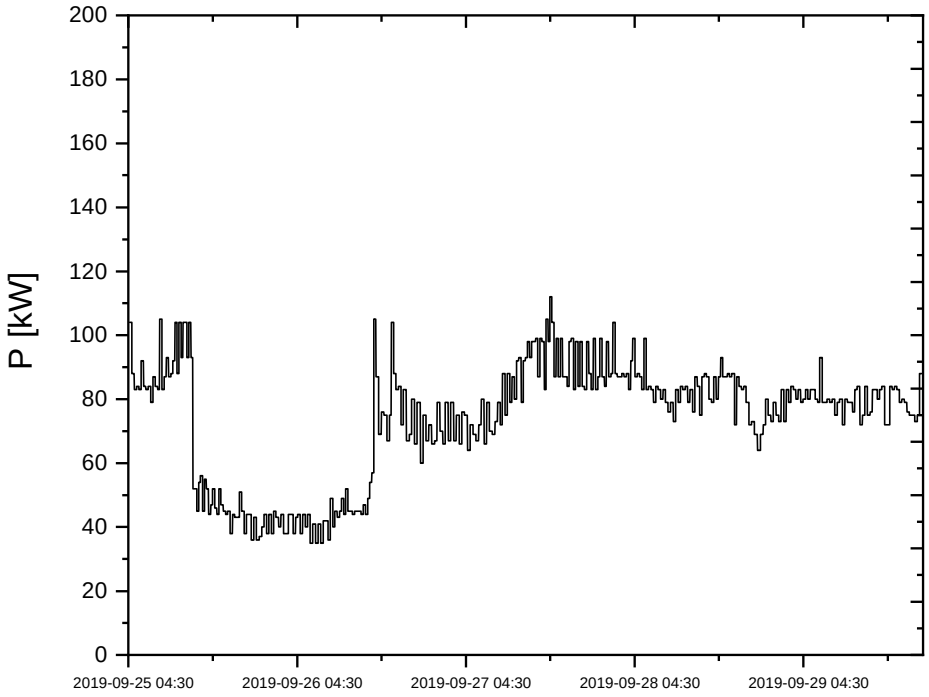


Figure 15. Heat consumption of IMP building in Gdańsk in the period 25.09.2019 – 29.09.2019.

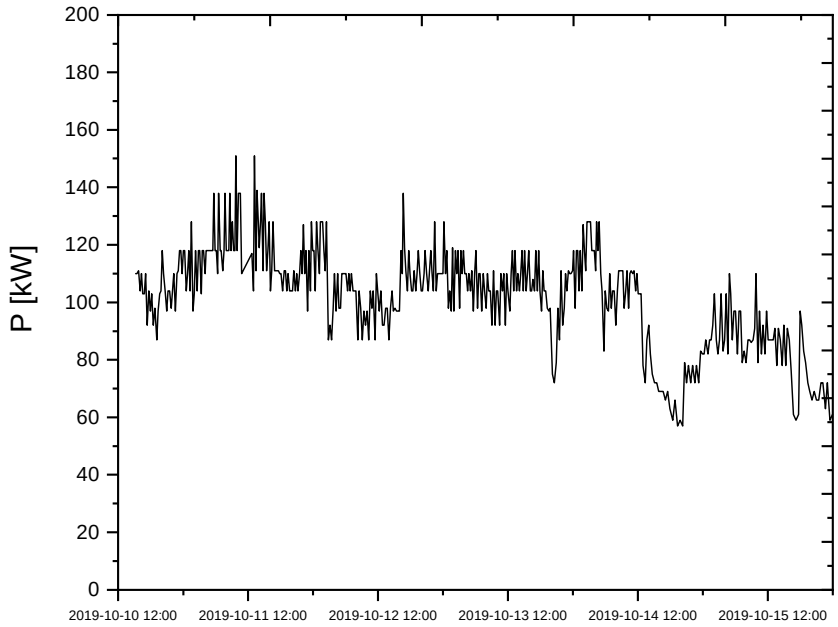


Figure 16. Heat consumption of IMP building in Gdańsk in the period 10.10.2019 – 15.10.2019.

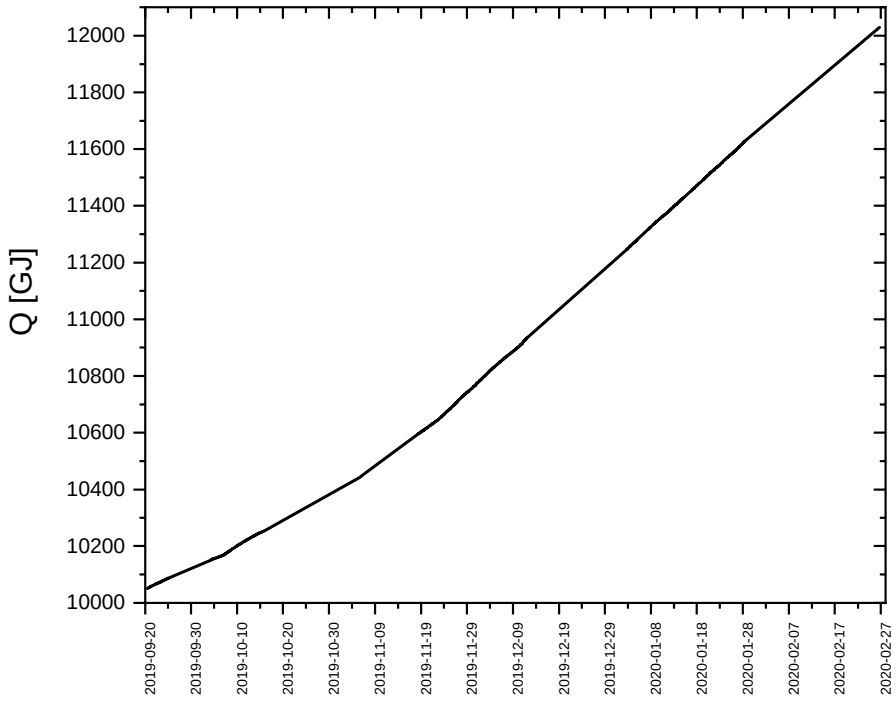


Figure 17. Total heat consumption of IMP building in Gdańsk in the period 20.09.2019 – 27.02.2020.

4.5.1. Beneficiaries and benefits

The developed energy monitoring system is addressed to municipalities in Poland and in other European (BSR) countries, especially in Eastern European countries. It is a very cheap way to add a modern interface to existing infrastructure and gain necessary measurement data in a simple way.

After the project finalization the system will be continuously maintained (it is installed in the IMP building and there will not be any technical or legal issues which can interfere with further development). The measurement results will be continuously uploaded to a database hosted on a server that can be accessed from any place in the world. In case of suitable conditions, data from more buildings included in the measurement net will be accessible online.

It is well known that energy monitoring system enables the energy use analyses and undertaking measures to increase energy savings and energy efficiency. This may stimulate municipality to implement building management systems (BMS) to profit from the gathered knowledge. By increase of energy efficiency there will be a big benefit in environmental terms.

4.5.2. Description of the implemented technology/solution/software within the investment(s)

Gdynia has purchased and installed air quality meter COMET U440M, shown in figure 18.

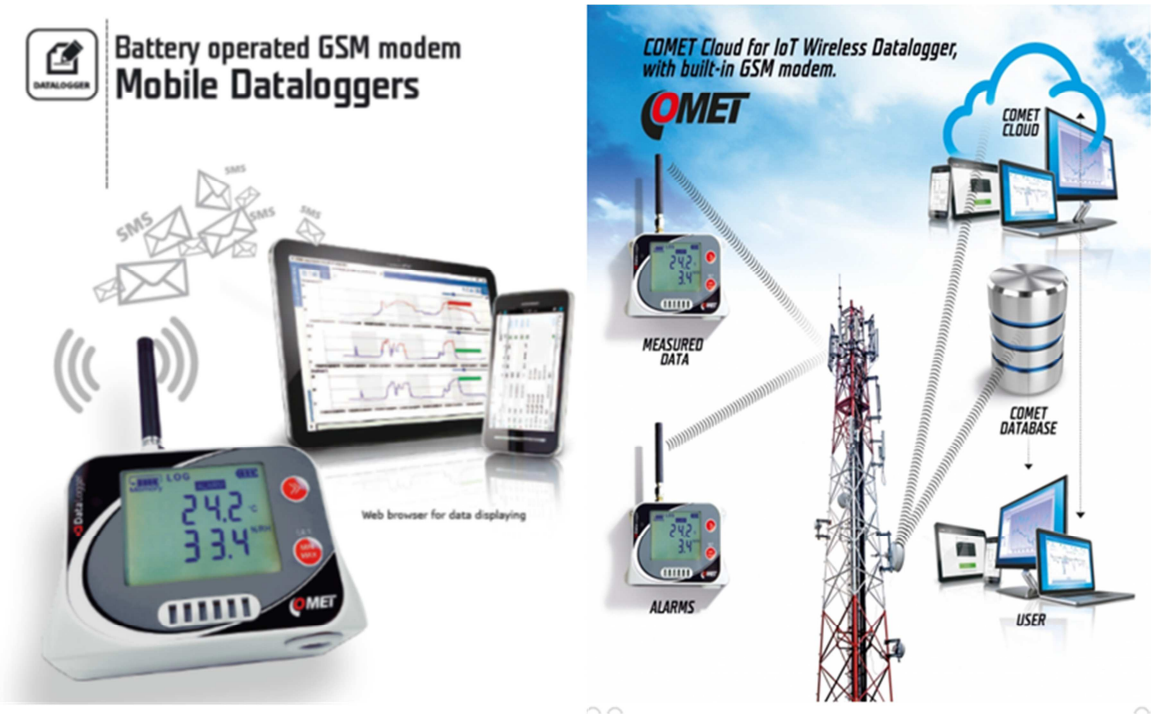


Figure 18. Air quality meter COMET U440M.

The innovative solution in IMP PAN has two layers that will be described hereafter.

- The hardware layer is fairly straightforward. It consists of the Raspberry pi4 computer illustrated in (see **Fehler! Verweisquelle konnte nicht gefunden werden.**19)

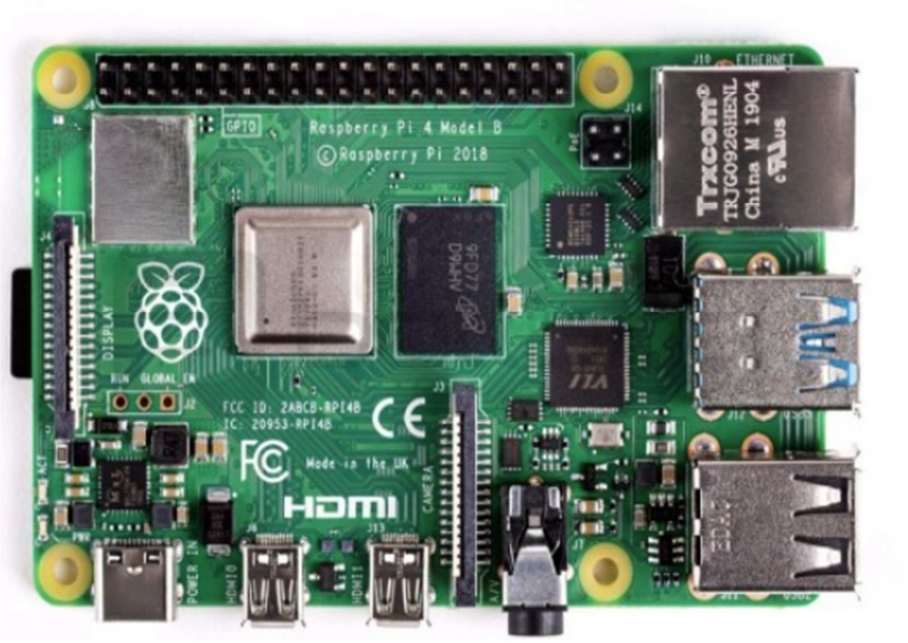


Figure 19. Raspberry Pi4 computer.

- And the V2.1 camera module that is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**20.

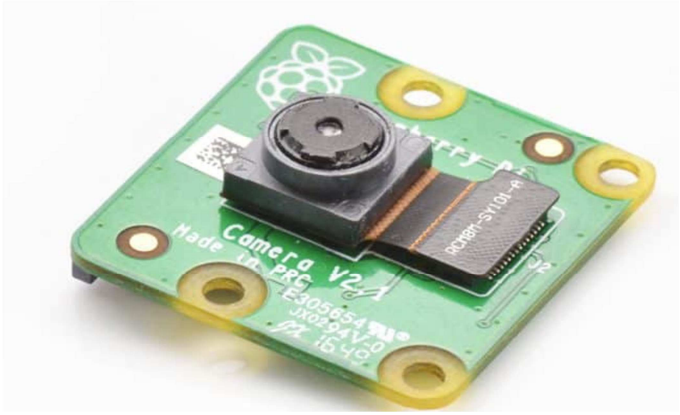


Figure 20. Raspberry Pi V2.1 camera.

The task of the hardware layer is to be an environment for a Python 3 application to run and to supply camera interface and access to the Internet. The software layer is entirely developed by IMP PAN using only free tools and libraries. It has absolutely no legal restrictions of any kind, thus the project implementers are owners of the whole software and we are free to use or modify it in any way.

The software is developed in Python 3 with the use of openCV library. The application main infinite loop consists of the following tasks:

1. take a photograph,
2. recognize the digits in the taken image (custom OCR),

3. send the resultant value to database,
4. wait 10 minutes (the interval is of our choice).

Stage 1. ‘Take a photograph’ is realized using the openCV command; the image is stored as a three dimensional numpy array (with three color channels).

Stage 2. ‘Recognize the digits in the taken image (OCR)’ - this uses two applications. The first one prepares a pattern of the desired point of view of the display. It shows the real time view from the camera like in **Fehler! Verweisquelle konnte nicht gefunden werden.**21.

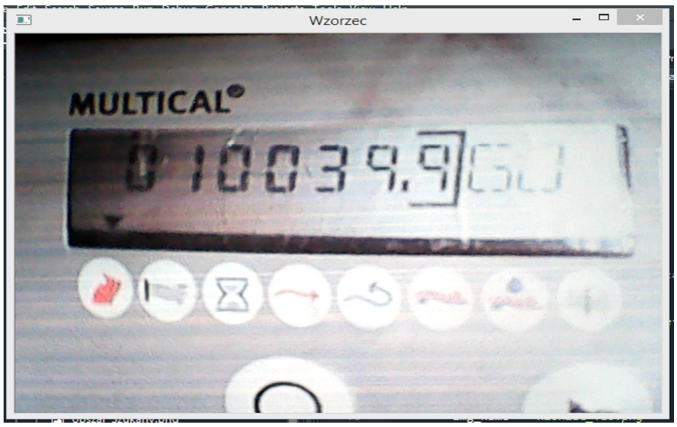


Figure 21. Display view for preparing desired point of view settings.

The image is a view of the ‘KAMSTRUP’ heat meter (located in IMP) used at measurement site. Once the view is satisfactory, the region of interest for features analysis is to be selected as illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.**22.

Figure 22. Selecting region of interest for feature extraction.

In the next step, the region of display should be indicated, like in **Fehler! Verweisquelle konnte nicht gefunden werden.**23.

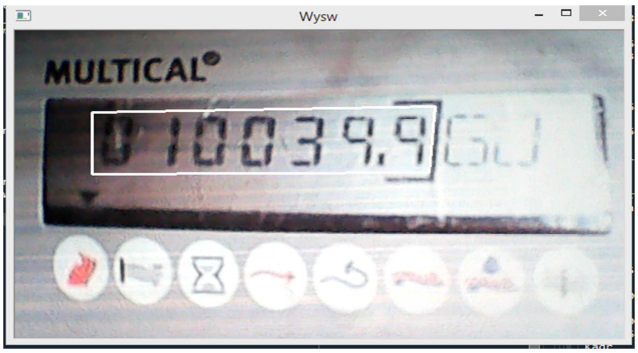


Figure 23. Excluding the variable region.

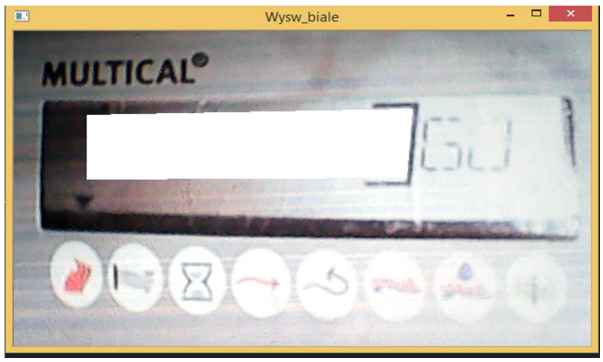


Figure 24. Desired point of view, region selected for feature extraction.

The selected region is changing and should not be taken into account when performing the feature analysis for calculating the homography. The features are extracted from the region depicted in **Fehler! Verweisquelle konnte nicht gefunden werden.**24. Such image has to be taken only once prior to installing the system, so the light and position of the camera can be set to get a high quality image. The installed system can have a very different point of view and light. Once this is done, appropriate data is saved as graphical file containing the image taken from the desired point of view and in JSON file.

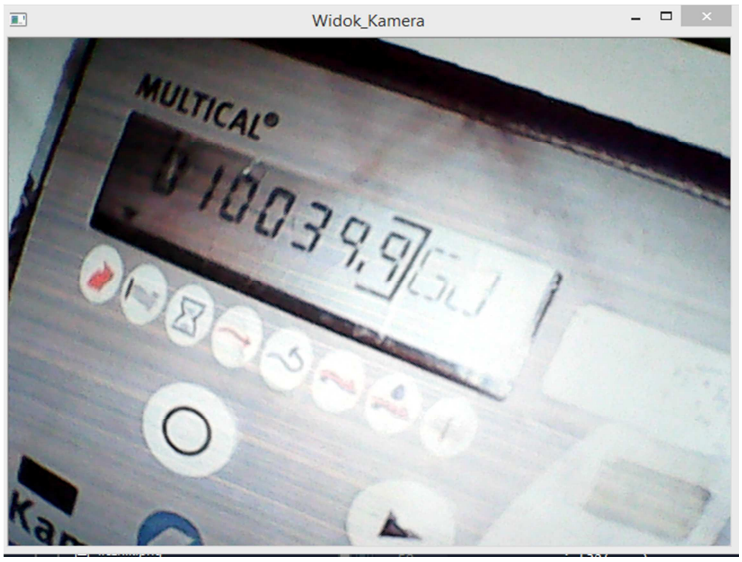


Figure 25. Actual frame taken at the site.

The second system reads the value on the display (marked in figure 23), no matter what is the mutual position of the meter and the camera, also changes in the lightning are overcome by the system. As a result, the system is resistant to changes in the surrounding and to changes of position of the camera with respect to the meter. Such changes are almost inevitable when installing the system in locations that were not intended to be used for such purpose, also it is often impossible to predict the distance or angle of view that the camera will be installed. An actual image taken from an almost random position of the camera is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**25.

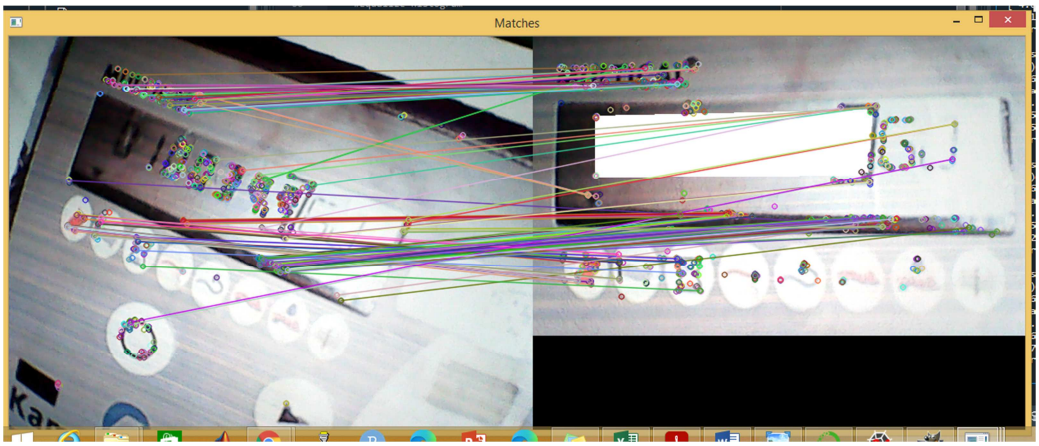


Figure 26. Feature extraction and matching.

The software now extracts features in the frame that are invariant to scaling, spatial rotation and light variation. Once they are found and described, the search for corresponding features in the image are taken from the desired point of view. Thousand features are analyzed, and 15 of highest mutual correspondence are taken into account for aligning the images. The result of feature extraction and matching is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**26.

Based on the positions of corresponding points in template image (**Fehler! Verweisquelle konnte nicht gefunden werden.**22) and the current frame (**Fehler! Verweisquelle konnte nicht gefunden werden.**25) a

matrix of homography is calculated. It describes a transformation changing the current point of view of the camera to give the view like in template image. Applying it to the frame results as transformation to image illustrated in figure 27.

Figure 27. Transformed frame.

The benefit is that in this frame the position of the display is exactly the same as it was in **Fehler! Verweisquelle konnte nicht gefunden werden.**25. To visualize it, a yellow frame has been marked. The position of vertexes is taken from the one in **Fehler! Verweisquelle konnte nicht gefunden werden.**24 and the correspondence is very precise. For a quick verification also a matrix of inverse homography is calculated and the image of frame is imposed onto the real-time frame, as illustrated in

Figure 28. Inverse homography test result.

28.

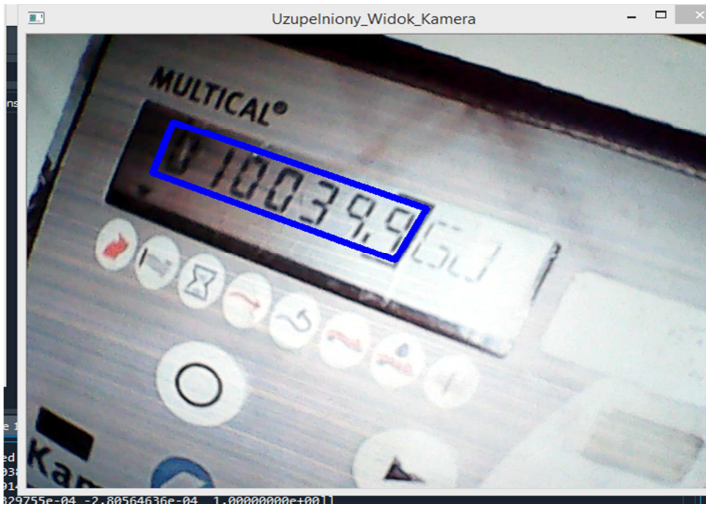


Figure 28. Inverse homography test result.

Having reconciled the coordinate systems of the frames being taken (that can be changing from frame to frame) and the template, the region of display can be easily found, as in

Figure 29. Region of display in actual frame.

29.

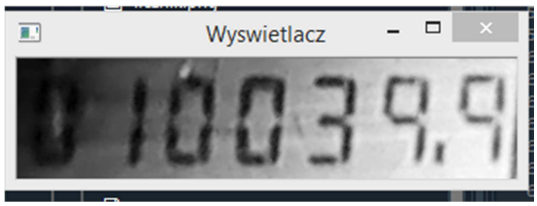


Figure 29. Region of display in actual frame.

The region of display in actual frame is found by simply using coordinates of vertexes given in the template image in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Due to applying the homography transformation, the position of the display in every frame is exactly the same, no matter of the position of the camera when taking this frame. In order to make it less demanding for the OCR the histogram equalization is conducted. The CLAHE algorithm being a variant of Adaptive histogram equalization that takes care of over-amplification of the contrast has been applied. The view of display from figure 29 after running the CLAHE process is given in figure 30.

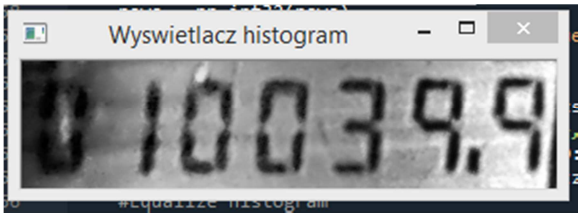


Figure 30. Display image with CLAHE equalized histogram.

The improvement of contrast is very significant, also the light uniformity is better, allowing for effective binarization of the image (Figure 31. Display binary image.

).

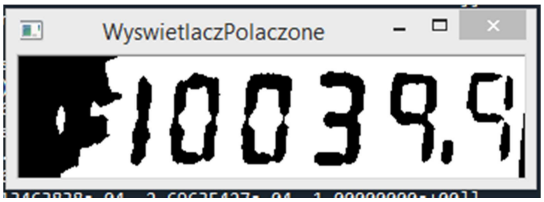


Figure 31. Display binary image.

The binarized image is read by applying bit masks marked with blue solid lines as shown in figure 32.

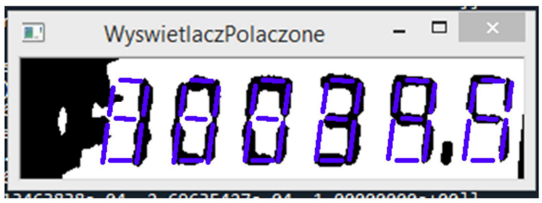


Figure 32. Display image with bit masks of segments.

Using threshold of 127, each segment of every digit is defined as either on or off and the number that is displayed is found. The value is stored in the non-volatile memory of the computer and uploaded to a remote SQL database together with a timestamp.

4.5.3. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

The proposed system is a prototype, but it is related to EnMS application in capacity building scheme support by undertaking the actions necessary to reduce energy consumption by means of maintenance of municipal buildings and possibly also behavioural actions. The gained knowledge can be used by municipal authorities to initiate efficient energy- actions.

The strategy for Gdynia related to EnMS systems is being developed. The results of the investigation made within the project helped Gdynia to make final decision.

As to tenders prepared by municipality were unsuccessful, IMP PAN decided to implement the system in the building of IMP PAN and avoiding any decision made by municipality in this respect.

Instead of EnMS, Gdynia has decided to buy the systems which enables the monitoring of air quality in schools. The information obtained by means of the recorders, has been analyzed by experts from the Institute of Fluid-Flow Machinery of the State Academy of Sciences, who are partners of the *ActNow!* project. Conclusions from the analyses will be used to prepare recommendations for improving the comfort of building users and better energy management. Users of building under study will be taught how to manage energy efficiently to minimize energy consumption without sacrificing the comfort of use.

4.6. Gdynia PKT (Poland)

Energy Monitoring and Management System in the trolleybus depot

4.6.1. Summary of the pilot investments

Partners /Beneficiary involved: PRZEDSIEBIORSTWO KOMUNIKACJI TROLEJBUSOWEJ SP. Z O.O. / PP6

Name of Pilot Testing Measure: Energy Monitoring and Management System in the trolleybus depot

Location of Pilot Testing Measure: addresse(s): Przedsiebiorstwo Komunikacji Trolejbusowej Sp. Z O.O.

Ul. Zakret do Oksywia 1, 81-244 Gdynia, Poland

Owner of the investment: Przedsiebiorstwo Komunikacji Trolejbusowej Sp. Z O.O. (trolleybus transport operator in Gdynia, a municipal company in 100% owned by the Municipality of Gdynia)

Coaching partner: SZEWALSKI INSTITUTE

4.6.2. Background

PKT Gdynia, a public transport operator in the city of Gdynia (trolleybuses and battery trolleys), is a large municipal enterprise which employs 410 persons. Its headquarters are in the depot (an office and workshop building of total 3737,25 m^2). The construction of depot was also co-funded by EU funds and officially handed to service in 2007. Depot building is the main focus of *ActNow!* as within the project PKT performed an investment in the Energy Monitoring and Management System aimed at increasing the building's energy-efficiency.

The EnMS in Gdynia trolleybus depot is a tailored-made solution - a computer aided data archiving and monitoring system with particular control devices. The system installation was preceded by necessary modernization of existing installations in the building to make some parts „steerable" (which they haven't been before).

Before the installation of the EnMS the knowledge of the depot building's energy consumption was very basic and virtually nothing was known about the depot's energy consumption in particular zones. PKT knowledge depended solely on the analysis of general invoices and manual reading of data from the following meters:

- main electricity meter,
- main heat meter,
- main water meter.

4.6.3. Main problem to be addressed

The overall data gathered from invoices and general meters did not provide sufficient information about energy consumption in the building, nor indicated the areas with the biggest energy losses.

Whereas now this problem has been offset. After the completed implementation of a smart energy metering and management system in the trolleybus depot building real-time data is being automatically and regularly collected by several heat and electricity submeters. The data shows exactly in which zones in the building how much energy is consumed. The system implementation is expected to make the energy management on the company premises far more transparent, cost-driven and effective and thus considerably reduce the heat and electric energy consumption in the building (even up to 20-30%).

4.6.4. Aim and scope of the pilot investment

The investment of PKT comprises the installation of Energy Monitoring and Management System in the form of computer assisted facility management in the building of the trolleybus depot.

This installation allows to increase the monitoring and control of the heat node as well as heating, ventilation and lighting installations operation, and thus increase the energy efficiency of the building.

Below is reported the structure of the scope of the investment according to the energy monitoring system made in the depot building. Specifically central data switchgear with a programmed PLC controller connected to the building installations below were installed in 3 parts of the depo.

1. Heat node

- Heat node upgrade to prepare it to connection to EnMS (Central Data Switchgear).
- Data collection and registration of heat energy consumption broken down into:
  - ventilation,
  - workshop hall heating apparatuses,
  - air curtains,
  - office heating,
  - workshop heating,
  - hot water.
- Data collection and registration of electricity consumption for one's own needs.
- Data collection and registration of parameters and controlling the operation of the heat node.

2. Heating devices

- Heating devices upgrade to prepare to connection to EnMS (Central Data Switchgear).
- Data collection and registration of working parameters and correction of settings of:
  - air handling units,
  - air curtains,
  - workshop hall heating apparatuses.
- Registration of electricity consumption of individual devices.

3. Monitoring of electric energy

- Monitoring of electric energy in selected circuits of the depot's electrical installation, such as lighting circuits.

The innovative element of the investment implemented is that it is a very effective solution for the buildings which were built without any energy management systems (but for very basic meters), like in the case of the building of PKT depot. A much more advanced energy monitoring and steering system

enables to collect more data about the facility and manage the energy consumption in the building better and more efficiently.

4.6.5. Investments timeline

The investment included several steps that were executed according to specific time line. The timeframes of the investment phases and the description of measures in PKT Gdynia is given in table 4.

Table 4. Timeframe and description of energy efficiency measures in PKT Gdynia.

Phase	Timeframe	Measure	Description	Status
1	*07.2017 - 06.2019*	*Pre-procurement solution analysis phase*	*Analysis of energy management needs of the depot building. Designing an EnMS solution tailored for the building. Conducting a market research on the availability of suppliers able to provide and implement the investment designed.*	*Completed*
2	*09.2018 - 11.2019*	*Procurement phase*	*By Nov. 2018 PKT already conducted a part of the planned investment (7 electric energy submeters were installed). In Nov. 2019 PKT finalised procurement and contracted a supplier for the biggest part of the investment.*	*Completed*
3	*12.2019 - 07.2020*	*Installation*	*Preparatory stage – Stage 0 – Installation of 7 additional electric energy submeters (Oct. 2018) – stage completed* *Stage 1 - Installation of 6 additional heat submeters at the main heat node in the depot building (previously there was only one general heat meter there). Additional submeters allow to collect data from the heating period, which is being used for real-time energy consumption analysis. (heat submeters installed in Dec. 2019)* *Stage 2 - Completion of all investment works and startup of the entire central archiving and control system for selected electrical and heating-ventilation installations in the PKT depot building.*	*Completed*
4	*03.2020 - 11.2020*	*Data collection*	*Data has been regularly collected from the installed 7 electricity submeters and 6 heat meters. Analysis have been conducted.*	*Completed*
5	*07.2020 – 10.2020*	*Data processing/analysis System optimization*	*Cooperation with the contractor has continued to calibrate the EnMS functioning and tailor it according to the PKT depot building conditions and needs so*	*Completed*

			that it serves its purpose most efficiently.	

4.6.6. Beneficiaries and benefits

PKT first directed beneficiary from the installation of the Energy Monitoring System in the depot building. After the investment prescribed by the framework of *ActNow!* the depot building is now equipped with an installation that allows increased control of the heat node as well as heating and lighting installations.

Installation for measuring and controlling energy consumption in PKT depot allows for collecting and archiving data on:

- the amount of heat energy consumed by individual elements of the heat installation,
- the amount of electricity consumed, i.e.:
  - in building heating installation devices,
  - in representative lighting circuits (offices, workshop hall, corridors, etc.)
- on parameters registered, such as:
  - outside temperature,
  - internal temperature in the given zones of the building,
  - selected temperatures in the hot water installation,
  - current heat energy consumption,
  - other.

Therefore, for the first time it is possible to determine how much energy is consumed in specific parts of the building, which gives vast knowledge for better energy management in the building and show areas where there is the biggest need to intervene by setting parameters differently or modernizing the installations to prevent further energy losses.

To sum up, planned benefits arising from installing energy consumption measuring and control installations are:

- increased knowledge about energy consumption in individual parts of the building by collecting individual data
- possibility to analyse collected data in terms of developing optimal installation settings (combination of ecology, economy and comfort).
- setting direction for the possible further expansion of the system for measuring and control of energy consumption, as well as directions for further modernization of heating and electrical installations in the depot building in order to increase energy efficiency in the building.

Thus, the greatest benefit resulting from the investment is that way of controlling and managing energy in the building has become considerably more advanced.

However, there are more benefits and beneficiaries emerging from this investment:

- the EnMS system maintained by PKT can be further extended and developed to a more mature and advanced form in the near future, and thus bringing even bigger energy savings,

- what is more, the state-of-the-art EnMS implemented may serve as lighthouse example in the city, region and beyond as it can freely be replicated in other municipal buildings (not only depot buildings),
- clear and measurable environmental benefit – energy savings between 20-30%.

4.6.7. Description of the implemented technology/solution/software within the investment(s)

The following EnMS implementation phases were realized.

- Phase A. In connection to Part 3 of the investment (i.e. Monitoring of electric energy)

In October 2018 PKT carried out the installation of submeters for measuring the consumption of electricity in the lighting circuits of selected zones in the depot building, complementing previously used one general electricity meter.

Since 11/10/2018 the company has been keeping a journal log of electricity consumption readings for selected lighting circuits in the depot building, i.e:

- RT1 - lighting of parts of the workshop hall and maintenance tunnels - track No. 1 - daily service of trolleybuses;
- RT2 - lighting of parts of the workshop hall and maintenance tunnels - track No. 2 - daily service of trolleybuses;
- RT3 - lighting of parts of the workshop hall - track No. 3 and 4 - technical service;
- RT5 - lighting of parts of the workshop hall – track No. 3 and 4 - technical service;
- RT8 - lighting of parts of the workshop hall – track No. 3 and 4 - technical service;
- RT10/P4 - lighting of parts of corridors (passageways) and specialist workshops (electronic's, tool warehouse, tinsmith's, upholsterer's, etc.);
- RT11 - lighting of parts of corridors (passageways) and offices (depot master's office, WSiP office, supply office, etc.) and the main warehouse.

The archiving of the meters' readings above is being used to perform calculations and draw conclusions regarding the electricity consumption needed to illuminate individual spaces in the depot building.

The calculations concern, among others:

- the amount of energy consumed for individual lighting circuits,
- analysing the energy consumption of selected lighting circuits in relation to the duration of the day,
- analysing the energy consumption in relation to the function of the rooms, which they are illuminated by the given circuits,
- other necessary calculations that will indicate for example the direction of lighting installation modernization in the PKT depot as well as blending it into Energy Monitoring System of the building (for example the exchange of traditional fluorescent bulbs to LED bulbs).

- Phase B. After signing the contract with the company chosen in the tender (contract was signed in December 2019) next stage of work was carried out (referring to Part I of the investment described in the diagram in point 1.3 of this report – Heat node).

In December 2019 six additional heat substation meters were installed (previously there was only one main heat meter for the entire facility, on the basis of which PKT settled accounts with the heat supplier).

At present, in addition to the main heat meter, in the building there are new 6 heat substation meters corresponding to the following building areas:

1. Installation of central heating (radiators) in the administrative part of the building (office).
2. Installation of central heating (radiators) in the workshop part of the building (metal, upholstery, warehouse, tool shop, electronic workshop, etc).
3. Mechanical ventilation - installation of heaters in the building's mechanical ventilation centers,
4. Central heating with heaters – workshop hall,
5. Curtain heaters at the entrance gates of the inspection hall part,
6. Hot running water in the building.

These six additional heat submeters are used now to measure and archive data on building heat distribution.

After the implementation of phase A and B of the investment, the collection and archiving of data from the new six additional heat meters and previously installed seven electricity substation meters (in Oct. 2018) was currently done manually.

Phase C. In the final stage of the investment, which was completed by the end of June 2020, the contractor installed a central control and archiving system for the data from the above mentioned heat node substation meters and electricity substation meters. After the implementation of the last stage of the investment, data archiving is now centralised, automatic and visible in one computer stand (or other device such as a smartphone, as well as special interactive display placed in the heat node room).

In addition, in the final phase necessary modernization of some devices has been executed in order to make them “steerable” and able to be connected and controlled by EnMS. Thus, 13 heaters of the workshop and inspection hall as well as the car wash room were replaced with new, more efficient devices equipped with an automatic central control system in place of the existing manual stationary controllers. Data from the operation of new heaters (e.g. temperature in a given zone) was also be connected to a central energy management system visible on one computer.

After the complete investment implementation, for the first time in selected parts of heating and electrical installations in the depot building data is automatically archived. Moreover, automatic control and steering system of these installations is in operation, all handled from one computer aided control station.

After the implementation of the final stage of the investment PKT is able to indicate on a current basis whether a given part of the heating system is working properly and optimally and whether there is, for example, a need to intervene in its functioning. Acquiring data on a regular basis, PKT is able to quickly capture and check whether there has been, for example, any leakage in the heating system or whether someone has not manually changed the parameters in the ventilation unit, e.g. from 16℃ ventilation air

temperature to 35℃ in an unauthorized manner, and thus causing unnecessary energy losses. If there was no detailed data archiving and distinguished individual parts of the heating and ventilation installation, these irregularities causing energy losses would be very difficult to detect.

What is also essential, the depot building EnMS system has been economically reasonable investment as it is based on Schneider Electric software which comes free of charge when ordering this producer's PLC sensors.

Thus, to sum up, the current system offers several important technical functionalities, which are now effectively used by PKT:

1. Archiving the internal temperatures of the workshop hall and the external temperature allows to determine the outside temperature at which it is reasonable to turn off or turn on the heating system circulating pump (according to the current data, it is 14℃). This is the temperature at which the building insulation maintains the set internal temperature (16℃) resulting from the obliging standards and regulations and not affecting the comfort of work.

2. The system enables remote temporary reduction of the temperature of the heating sources (e.g. radiators) in particular areas of the building according to the employees' work schedules. For instance, in the offices, when there are no employees, e.g. during the weekend or at longer breaks (Christmas, Easter, banking or national holidays etc.) temperature reduction incur significant energy savings. The system allows for introducing a standard automatic setting of a higher temperature, for example, 2-3 hours before the employees arrive at the offices. Currently, the most optimal settings are being checked, which will bring savings, but simultaneously will not reduce the comfort of work of office workers. Considerable savings are expected from this functionality (Fig 2).

3. Similarly, the data on hot water consumption is being used to apply a reduction in the hot water temperature when workshop employees do not use showers (according to their work schedules). As an experiment, during the summer the building manager has intentionally lowered the highest temperature of hot water in the building from 50 °C to 47 °C (at times when employees take showers) and 44 °C (otherwise) and no complaints about the comfort have been noted so far. Thus, at the moment data and experience are being collected and cost savings are also expected in this area.

4. Based on the analysis of the recorded data PKT is now able to use individual elements of the heating system of the workshop hall more effectively. Data collected so far indicate that at the outside temperature between 8 °C - 14 °C in order to maintain the desired internal temperature of the workshop hall (16 °C) is perfectly sufficient to preliminarily prepare (heat) the air of the mechanical ventilation and turning on the workshop hall-heaters is not necessary, anymore. Huge savings are expected from this discovery as well.

5. The system also provides the possibility to assess whether new innovations or solutions planned to be implemented in the depot buildings heating or lighting system could bring both reasonable and measurable energy savings. For example, thanks to the data registration from lighting circuits electricity, now it is possible to check what savings will be brought by the exchange of conventional energy saving fluorescent light bulbs to LED bulbs. Recently, one conventional fluorescent light bulb (used commonly in the PKT depot) has been change to a LED bulb as the former has been already exhausted. At the moment, thanks to the data available from lighting circuits electricity submeters and the possibility to compare energy consumption of both type of bulbs, the analysis of benefits from changing conventional bulbs to

LED ones in the whole building was performed. Otherwise, without the implemented EnMS this would be impossible.

The illustrations of the implemented technology/solution/software within the investment are shown in figures 33, 34 and 35.

Figure 33. Main panel of the EnMS system installed in the heat node.

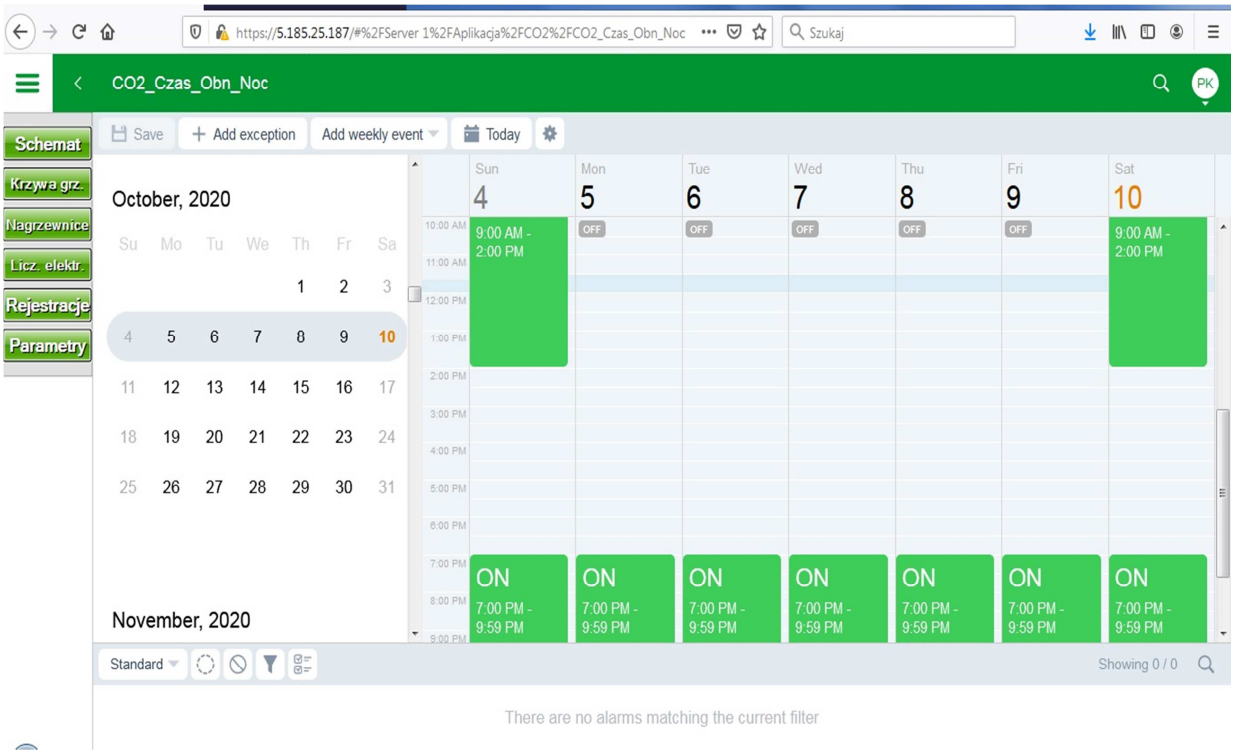


Figure 34. Introduced weekly pattern of temperature evolution in the administration part of the building.

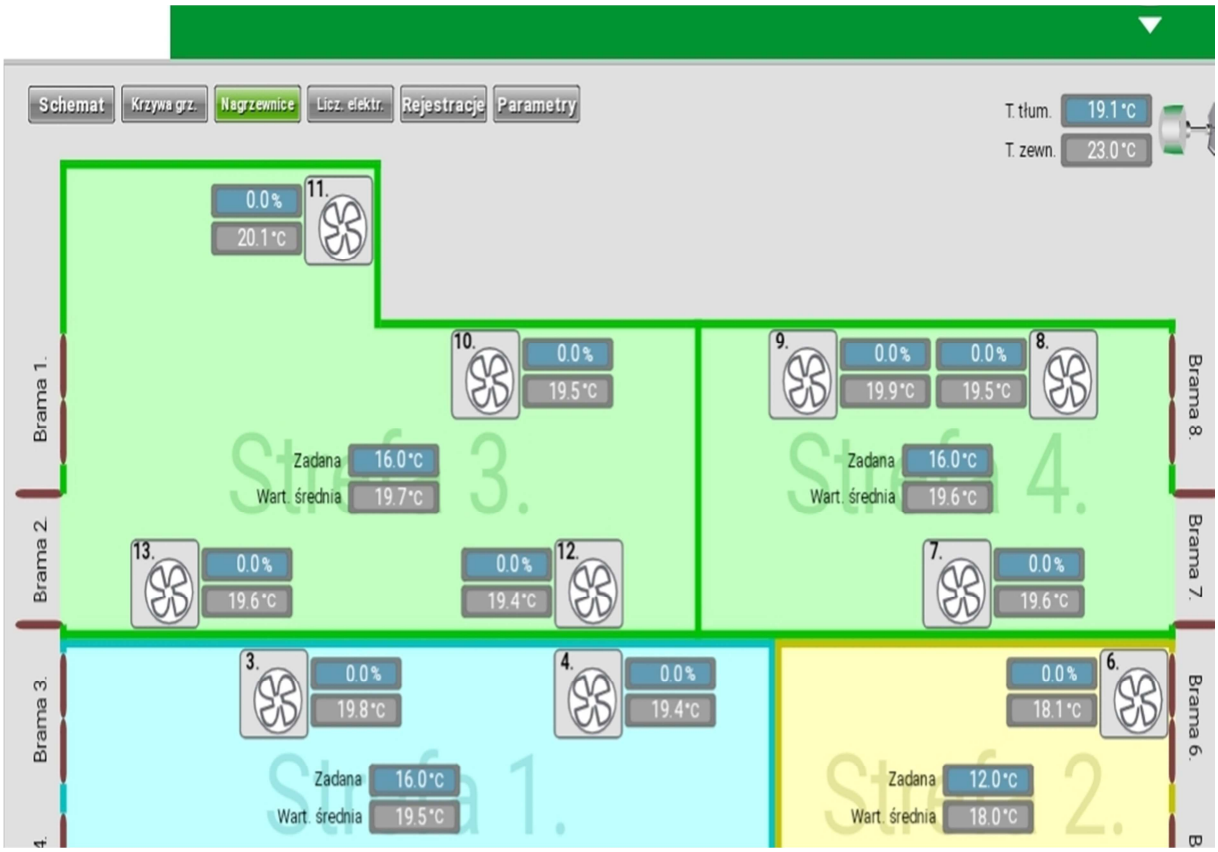


Figure 35. Division of the workshop hall into 4 separated zones.

4.6.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

PKT's investment complements the CBS as a replicable example.

4.6.9. Identified obstacle and barriers

Before contracting the company implementing the measure the greatest barrier turned out to be getting a supplier of the system from the market. EnMS is still quite a new idea on the Polish market, especially in relation to its installation to the older type of buildings.

The complete energy monitoring and management system that PKT intended to install required a range of assets from the company to be selected, namely:

- ability to modernize existing installation in the building in order to prepare them for energy management system installation,
- experience in providing individualized and tailored software for existing and modernized devices,
- ability to perform hydraulic installation works (among others related to installing the heat meters), as well as electrical works, ventilation works and works related to the implementation of the control system of individual devices and finally programming the controlling drivers of these devices and collecting them all in one central data switchgear.

Prior to procurement process a market research was conducted on the Energy Monitoring and Management System providers, who would be able to perform the remaining part of the planned investment of the necessary systems upgrade and then EnMS implementation in the PKT depot. PKT was gathering knowledge and solutions available on the market that can be used in its metering and management system for selected installations in the depot building.

PKT was actively searching for such a company since October 2018, and it appeared that there are only a few on the market. However, thanks to a deep market penetration PKT has managed to identify companies which might be interested in implementation of the investment and in September, October and November PP6 was preparing to a procurement phase.

Thus, on 15th November 2019 in accordance with the Sectoral Regulations obliging PKT LLC a tendering procedure was started by publishing a request for quotation regarding „Delivery, assembly, start-up and visualisation of the stationary central archiving and control system for selected electrical and heating-ventilation installations in the depot building of PKT LLC". On 29th November 2019 the tender procedure was resolved. There were two companies which submitted their proposals. The tender was won by the company (ALPAT from Gdynia), which offered a lower price for the subject matter of the tender, while still meeting all the tender requirements. On 5th of December 2019 a contract between PKT and ALPAT was signed. According to the request for proposal, the task was divided into two stages, as described in the contract:

Stage 1 - Installation of 6 additional heat meters at the main heat node in the depot building. The additional meters allow to collect data from the heating period, which will be used to prepare the final analysis. – the stage was completed in December 2019.

Stage 2 - Completion of all works and start-up of the entire central archiving and control system for selected electrical and heating-ventilation installations in the PKT depot building.

The second stage of works was not completed by expected date (it was meant to be completed by the end of March 2020) due to the delay caused by COVID-19 pandemic. Nevertheless, implementation of the whole investment as such within the project timeframe was not endangered by the delay and all the works were completed by the end of June 2020.

4.7. Kaliningrad (Russia)

Improving the existing EnMS through the introduction of an automated energy management system

4.7.1. Summary of the pilot investments

Partners/Beneficiary involved: Immanuel Kant Baltic Federal University/Kaliningrad City Administration

Name of Pilot Testing Measure: Smart City

Location of Pilot Testing Measure: Kaliningrad

Owner of the investment: Kaliningrad municipality

Coaching partner: Immanuel Kant Baltic Federal University

4.7.2. Background

The municipality has developed a traditional energy-saving management system: conducting an energy audit of the first level, with the results posted in the state geo-information system "Energy Efficiency" with information on energy consumption for the annual period of all buildings of the municipal institution, technical parameters of buildings and energy saving targets.

At the same time, the institution's energy manager analyzes the energy consumption of municipal facilities at the municipal institution level, develops energy-saving measures that are fixed in the institution's energy saving program, and then implements them subject to financing from own funds or from the federal, regional budget and, alternatively, PPPs.

This information is transmitted to the energy manager of the administration of the municipality, which integrates the programs of all municipal institutions into a single municipal program, taking into account the existing development programs of the municipality.

4.7.3. Main problem to be addressed

The existing energy management system had deficiencies associated with untimely and inaccurate reporting of energy consumption information (up to its absence) by municipal institutions on time. More than 10% of false information came, and this data could be the most significant for the decision-making process, which jeopardized the implementation of the energy saving program. The municipality has a large number of buildings, about 200, which are characterized by different classes of energy efficiency and

different dynamics of energy consumption, which also complicates the processes of energy saving management.

It is necessary to activate the work of energy managers at the local level, in municipal institutions. As a rule, the activities of energy managers are concentrated in the real current annual period of time and it is difficult for them to collect and refer to data on the energy consumption of municipal facilities for previous years, conduct a comparative analysis and develop optimal energy-saving measures. The manual method of providing information in the form of a questionnaire posted on a GIS (state information portal) was used. GIS is available for viewing only, excluding the possibility of analyzing data for all budgetary institutions of the municipality of Kaliningrad.

Therefore, there is a need for special tools for computerized energy monitoring, which will provide and automate the statistical analysis of energy consumption to develop the necessary energy saving measures.

Thus, the modernization of the energy management system is possible only after the introduction of the function of automated control of energy consumption.

4.7.4. Aim and scope of the pilot investment

Aim of investment is to improve the existing energy management system of municipality and achieve guaranteed energy efficiency indicators during the implementation of the municipal energy saving program.

Aim of our investment is reached by the implementation of two energy saving actions:

1. Software part. Introduction of a software product that collects energy consumption data from metering devices of buildings of municipal organizations and enterprises, followed by analysis of the dynamics according to the criterion of specific energy consumption per unit volume of the building to develop the necessary energy-saving solutions in the energy management system.

2. Hardware part. Originally installation of an automated heating unit for a private small-apartment house with heat capacity (heat Q = 0.05 Gcal / hour, hot water supply Q = 0.069 Gcal / hour), house and apartment energy meters was planned. The working group conducted an additional analysis of the implementation practices of such energy efficiency measures, which showed that increasing the energy efficiency class of small apartment buildings by two levels from very low to high due to the installation of a heating unit alone is not feasible without additional costs for warming the building facades. Facade insulation is a very expensive undertaking, which is impossible to implement within the existing budget. It was decided that this is not an effective investment, which cannot serve as an example for implementation at other facilities, so in this situation additional state support is needed. Final decision was to install only a common smart house meter for thermal energy in a 12-apartment building to show to the municipality that the system is operational.

The scope of the investment:

- a software product for an automated system for monitoring and metering of energy consumption (ASKUE), the cost is 470 000 RUR/5888,17 EUR;

- ASKUE software interface. In view of changes in legislation in terms of the form and data for reporting to the relevant federal authorities, there is a requirement to introduce changes in the ASKUE software interface, the cost is 480 000 RUR/6000 EUR;
- an expert module of the software, the cost is 1 000 000 RUR/12 500 EUR;
- a telecommunication component included, the cost is 100 000 RUR/1250 EUR;
- a computer, the cost is 100 000 RUR/1250 EUR;
- a common house smart meter for thermal energy to be installed in 12 apartment building, the cost is 165 000 RUR/2062 EUR. The purchase price includes: development of a meter installation project, equipment purchase, installation, testing and commissioning to a resource-supplying organization.

In total 2 315 000 RUR/28 938 EUR.

Hardware part. The innovative aspect is the use of a modern wireless interface for transmitting data from metering devices (LORA) - operating over a long distance and protected from interference.

Software. The innovative aspect is the implementation of an expert system (expert module of the software) for data analysis and processing with the subsequent development of possible energy efficiency measures. Usually similar ordinary software only performs a control function.

4.7.5. Investments timeline

Procurement*:*

- a software product for an automated system for monitoring and metering of energy consumption (ASKUE) from 28 February 2020 to 23 March 2020;
- ASKUE software interface from 16 July 2020 to 30 July 2020;
- an expert module of the software. The procurement procedure is planned for November – December 2020;
- a telecommunication component included. The procurement procedure is planned for November – December 2020;
- a computer. The procurement procedure is planned for November – December 2020;
- a common house smart meter for thermal energy. The procurement procedure is planned for November – December 2020.

Installation:

- a software product for an automated system for monitoring and metering of energy consumption (ASKUE) with the new interface was installed to the computer of IKBFU starting from 01.09.2020 to 14.10.2020. There were problems with access to the server equipment of the Kaliningrad City Administration due to pandemic. Energy manager and the relevant staff of the City Administration was introduced to the software and initial training was carried out, comments and suggestions on the operation of the software interface were considered;
- an expert module of the software. Installation is planned for January – February 2021;
- a telecommunication component included. Installation is planned for January – February 2021;
- a computer. Installation is planned for January – February 2021;
- a common house smart meter for thermal energy. Installation is planned for January – February 2021.

Data collection and Analysis*:*

September – October 2020. Data collection is finalized fully and data processing is partially realized. It is impossible to upload automatically the old (archived) data of previous years to our software, so this data is entered into the software manually from almost 1000 sheets of energy reports of municipal institutions. The process is partially realized. Planned to be finalized at the end of October 2020.

4.7.6. Beneficiaries and benefits

The main target groups are energy managers of the Kaliningrad municipal institutions and Kaliningrad City Administration' energy manager. In fact, this software would be of much interest to any energy manager of any municipality and organization of any form of ownership. The software will be also installed to the server equipment and similar EnMS system will be introduced in IKBFU as soon as the archived data of previous years will be uploaded to the software.

We are already now start testing this program in order to provide additional services to other municipalities - remote monitoring of the energy consumption of facilities with the development of recommendations and measures to reduce energy consumption, development or adjustment of the energy saving programs of municipal institutions and municipality' administrations.

4.7.7. Description of the implemented technology/solution/software within the investment(s)

1. Software part. A software product for an automated system for monitoring and metering of energy consumption (ASKUE).

A software product is the system of automated monitoring of energy consumption of municipal facilities (ASKUE). Dynamic monitoring of energy consumption - the possibility of introducing energy service financing instruments).

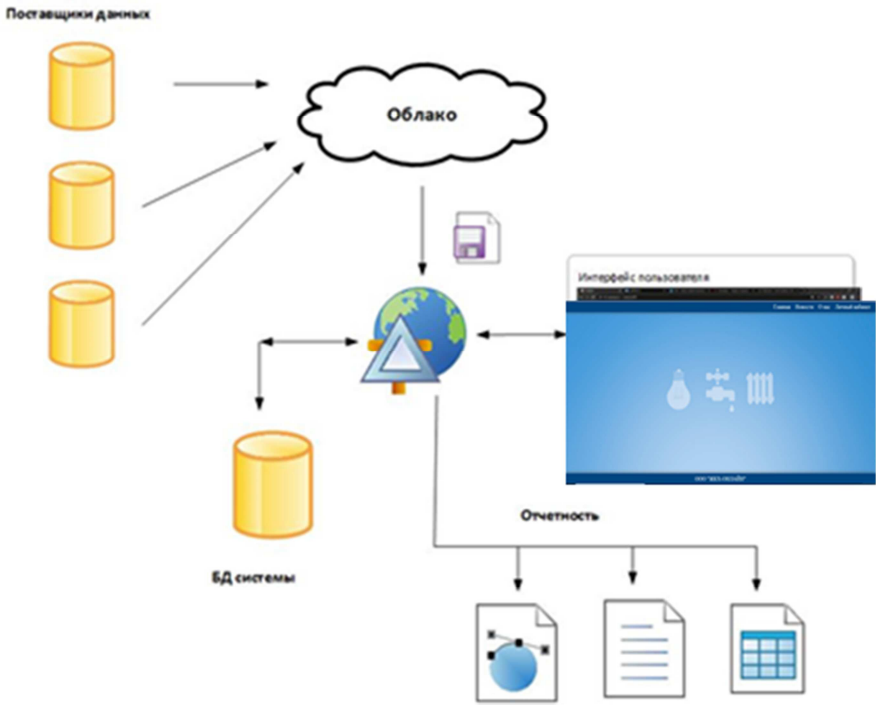


Figure 36. Structure of the system.

Aim: Development of an analytical tool to support decision-making in planning energy and resource saving measures and analysing the effectiveness of these activities.

Tasks:

- Collection and accumulation of data from resource-supplying organizations on consumption objects in physical and value terms,
- Maintaining a database of objects with a description of significant information,
- Accounting of planned and implemented measures on energy and resource saving,
- Reporting and analytical data generation,
- Monitoring the results of real savings by energy service organizations,
- Selection of objects suitable for energy service contracts.

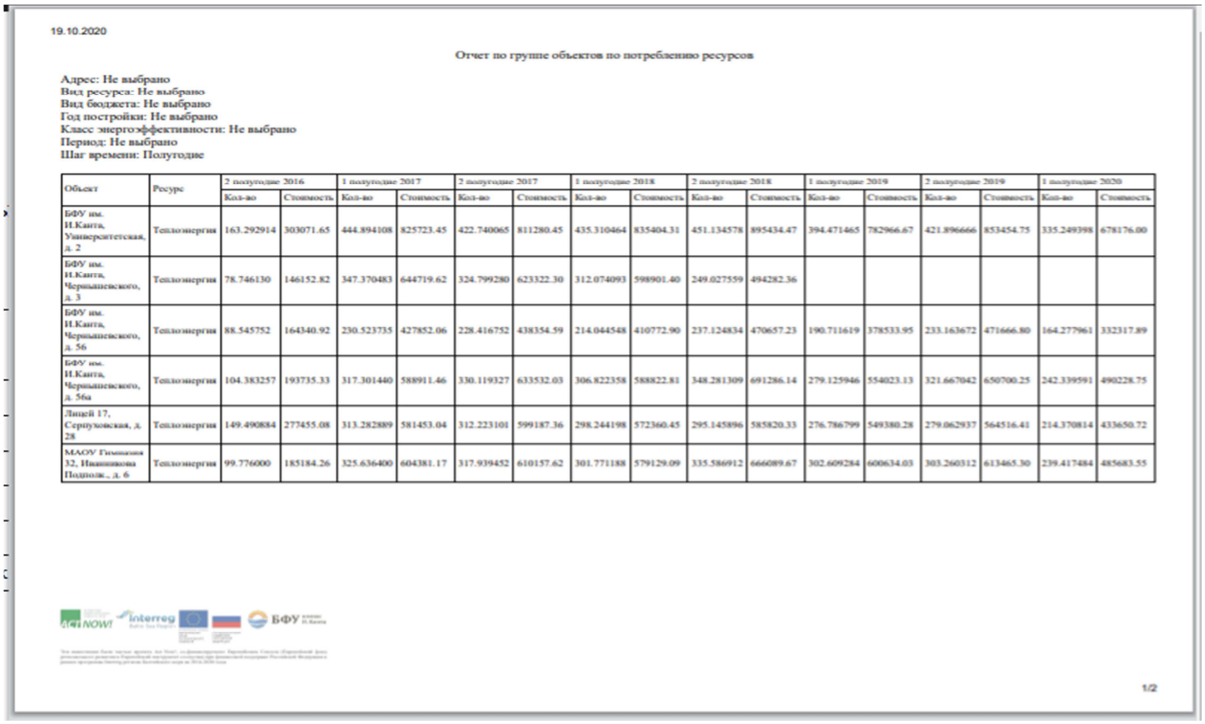
Functions:

- Collection of data from resource-supplying organizations in an agreed format and storage in the database,
- Maintaining a list of municipal facilities and relevant characteristics,
- Analysis of indicators of resource' and energy consumption, comparison with standard values,
- Planning of measures for resource and energy saving, assessment of the payback period of costs for measures,
- Accounting for the actual costs incurred for energy and resource saving and analysis of the actual payback period,
- Analysis of actual resource savings for energy service organizations,
- Formation of regulated reporting.

The system is built on WEB technologies using freely distributed software and uses PostGreSQL 9.6.3 or higher database management system (DBMS). Data is collected as follows: for a data provider, an energy supplier, a file processing template is defined. Files are transmitted by e-mail and then uploaded to the database for reliability assessment.

The data file is also stored in the file storage information. To use the obtained data, a user interface has been developed that allows you to work with data from system objects, control resource consumption and plan energy saving measures and control their implementation and analyze the results.

Figure 37. Main page.



19.10.2020

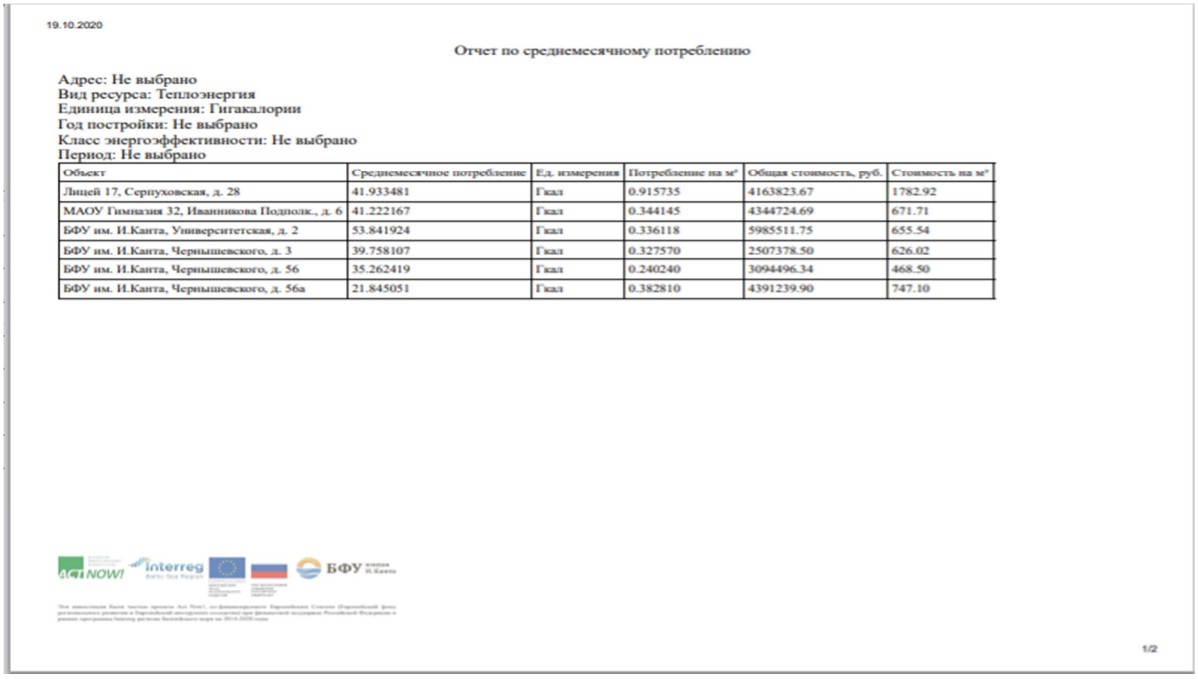
Отчет по группе объектов по потреблению ресурсов

Адрес: Не выбрано
Вид ресурса: Не выбрано
Вид бюджета: Не выбрано
Год постройки: Не выбрано
Класс энергоэффективности: Не выбрано
Период: Не выбрано
Шаг времени: Полугодие

Объект	Ресурс	2 полугодие 2016		1 полугодие 2017		2 полугодие 2017		1 полугодие 2018		2 полугодие 2018		1 полугодие 2019		2 полугодие 2019		1 полугодие 2020	
		Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость	Кол-во	Стоимость
БФУ им. И.Канта, Университетская, д. 2	Теплоэнергия	163.292914	303071.65	444.894108	825723.45	422.740065	811280.45	435.310464	835404.31	451.134578	895434.47	394.471465	782966.67	421.896666	853454.75	335.249398	678176.00
БФУ им. И.Канта, Черняховского, д. 3	Теплоэнергия	78.746130	146152.82	347.370483	644719.62	324.799280	623322.30	312.074093	598901.40	249.027559	494282.36						
БФУ им. И.Канта, Черняховского, д. 56	Теплоэнергия	88.545752	164340.92	230.523735	427852.06	228.416752	438354.59	214.044548	410772.90	237.124834	470657.23	190.711619	378533.95	233.163672	471666.80	164.277961	332317.89
БФУ им. И.Канта, Черняховского, д. 56а	Теплоэнергия	104.383257	193735.33	317.301440	588911.46	330.119327	633532.03	306.822358	588822.81	348.281309	691286.14	279.125946	554023.13	321.667042	650700.25	242.339591	490228.75
Лицей 17, Серпуховская, д. 28	Теплоэнергия	149.490884	277455.08	313.282889	581453.04	312.223101	599187.36	298.244198	572360.45	295.145896	585820.33	276.786799	549380.28	279.062937	564516.41	214.370814	433650.72
МАОУ Гимназия 32, Ивашинкова Подполк., д. 6	Теплоэнергия	99.776000	185184.26	325.636400	604381.17	317.939452	610157.62	301.771188	579129.09	335.586912	666089.67	302.609284	600634.03	303.260312	613465.30	239.417484	485683.55

1/2

Figure 38. Formation of regulated reporting, Example 1.



19.10.2020

Отчет по среднемесячному потреблению

Адрес: Не выбрано
Вид ресурса: Теплоэнергия
Единица измерения: Гигакалории
Год постройки: Не выбрано
Класс энергоэффективности: Не выбрано
Период: Не выбрано

Объект	Среднемесячное потребление	Ед. измерения	Потребление на м²	Общая стоимость, руб.	Стоимость на м²
Лицей 17, Серпуховская, д. 28	41.933481	Гкал	0.915735	4163823.67	1782.92
МАОУ Гимназия 32, Иванникова Подполк., д. 6	41.222167	Гкал	0.344145	4344724.69	671.71
БФУ им. И.Канта, Университетская, д. 2	53.841924	Гкал	0.336118	5985511.75	655.54
БФУ им. И.Канта, Чернышевского, д. 3	39.758107	Гкал	0.327570	2507378.50	626.02
БФУ им. И.Канта, Чернышевского, д. 56	35.262419	Гкал	0.240240	3094496.34	468.50
БФУ им. И.Канта, Чернышевского, д. 56а	21.845051	Гкал	0.382810	4391239.90	747.10

1/2

Figure 39. Formation of regulated reporting, Example 2.

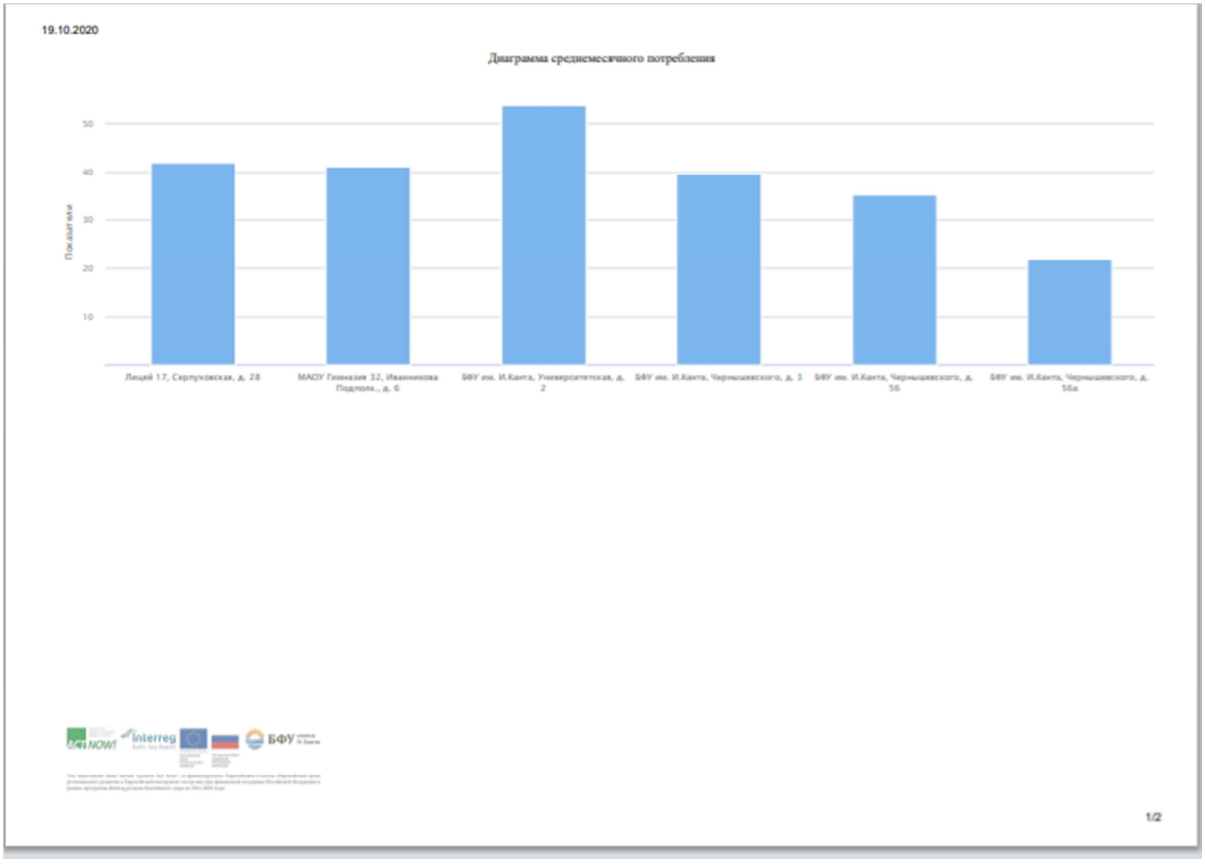


Figure 40. Formation of regulated reporting, Example 3.

Expected results:

- Efficiency of obtaining data on resource consumption,
- Presentation of materials for analysis in a convenient form (tables, graphical presentation),
- Support for the decision on planning energy saving measures,
- Monitoring the results of implemented energy saving measures,
- Monitoring the implementation of energy service contacts in terms of actual indicators.

Success:

- Guaranteed operation of the municipal energy management system,
- Improvement of energy efficiency indicators by approximately 10%.

2. Hardware part. Installation of a common house smart meter for thermal energy with two interfaces: one – old standard and the other - new standard Firth Generation Interface.

Aim: demonstration (testing) of the possibility and reliability of information transmission over fifth generation networks (LoRaWAN) and showcase to the municipality that the system is operational. The installation of such smart meters requires a large investment that cannot be achieved within the framework of this project. This is a future project to modernize existing metering devices of municipal institutions to ensure efficient operation of the energy management system. Example of the smart meter is shown in figure 39.

Figure 41. Example of the smart meter.

The investment is directly related to the energy management system. Investments in the program allow you to intensify the work of the energy management system through the automation of data collection and analysis.

The implementation of an expert system for data processing will allow to develop possible energy efficiency measures.

4.7.8. Connection of the investment to the CAPACITY BUILDING SCHEME (CBS)

The link of implemented investment with CBS as follows:

1. Macro-dimension: Energy Planning

Micro-dimensions and Capacity Building Trainings are foreseen:

- Monitoring and Analysing Energy Use. Lacks here and CBS needs: Lack of data analysis and awareness of energy consumption on an ongoing basis. Aim: To identify the most important factors that increase the energy efficiency of housing and utilities infrastructure through regular analysis, and use energy consumption monitoring data to form energy efficiency targets, their analysis and comparison with current energy consumption indications. Learning goals: Carrying out energy consumption analysis, reviewing current situation and setting targets. Adopted tool: Analysis, seminars. Performers: Project manager/LEEG members.
- Target Setting. Lacks and CBS needs: Lack of adjustment and formation of new targets based on energy efficiency analysis. Aim: To adjust targets to ensure consistency of analysis and energy efficiency. Learning goals: Analysis of energy consumption in order to set energy consumption targets, new legislative requirements in the field of energy saving. Adopted tool: Seminars/workshops/experience sharing. Performers: Top management in close collaboration with LEEG and energy manager.

2. Macro-dimension: Implementation

Micro-dimensions and Capacity Building Trainings are foreseen:

- Design. Lack and CBS needs here: Lack of analysis of data on energy consumption, lack of human resources and there is no possibility to control the energy consumption in real time in municipal buildings and street lighting. Aim: The collected data is not analyzed, and since the data is collected only monthly, it is impossible to estimate the critical points or atypical situations. Monitoring in real time will allow to see the maximum consumption, make comparisons and conclusions about energy losses and ways to save it. This requires certain knowledge and skills. Learning goals: Regular review and analysis of the collected data and bringing the results to the relevant groups, energy managers of municipal enterprises and organizations. Adopted tool: Seminars, conferences. Performers: Project manager/LEEG members, stakeholders, City council.
- Checking and Management Review. Lack and CBS needs: Energy management system isn't reviewed by the top management and city council at planned intervals. Aim: To ensure the stability, adequacy and effectiveness of the EnMS. Learning goal: Annual review of Energy management system. Adopted tool: Regular meetings of City council committees, annual review of Energy Policy, energy performance and related performance indicators; evaluation of compliance with legal or other requirements, reviewing the objectives and targets, follow-up

actions from previous reviews. Performers: Project manager/LEEG members, stakeholders, City council.

3. Macro-dimension: Infrastructure

Micro-dimension and Capacity Building Trainings are foreseen:

- Public Buildings. Lacks and CBS needs here: The absence of individual heat meters in each public or private building (which is planned to be used). Aim: To install an individual heat meter in each public or private building (which is planned to be used). Learning goals: Renovation of buildings and their heating system. Adopted tool: Renovation programs, private foundations and state support. Performers: Administration of the city district of Kaliningrad, City council.
- Public Buildings. Lack and CBS needs: Lack of automated control of energy systems (electricity and /or heat). Aim: To install automated energy management system (electricity and / or heat) in each municipal or residential building. Learning goals: Renovation of buildings and their heating system. Adopted tool: Renovation programs, private foundations and state support. Performers: Administration of the city district of Kaliningrad, City council.

The target groups are and will be trained in the application of the system as part of the identified capacity building scheme.

This was the decision of LEEG, fixed in the Minutes of the meeting.

At the meeting, a report was presented on the work of the existing energy management system, where it was noted the need to improve the existing system in terms of providing reliable and timely information by municipal institutions.

With the participation of the working group, a new energy saving program for 2020–2024 was developed, which forms the official energy policy of the municipality and is the baseline document for the operation of the energy management system.

4.7.9. Identified obstacle and barriers

It is very difficult to ensure the integration of energy consumption data from different suppliers due to the different format of presenting data. this format is not standardized and therefore we have to adapt and correct the data for entering into the software. It takes a lot of time and effort. We are still in the process.

There are difficulties with the communication with the Kaliningrad city administration due to pandemic. The site for installation of the software product to server computer is closed. Earlier as it was agreed during the online session to demonstrate the software and the city administration commented on their further expectations to consider and improve the software.

5. Transnational value of investments on EnMS

The transnational value within the implementation of specific investment for adapting energy management systems to the local needs was made according to the tailored municipality capacity building plan developed within the project *ActNow!* following the guidelines “Energy Efficiency Strategy for Buildings”. Within each capacity building scheme an option to select specific investments and make them

during the project implementation was included. The benefit of this activity was double-fold: on the one hand, it was possible to share technical knowledge among the coaching partners and the municipality already during the project implementation, on the other hand *ActNow!* project was triggering direct investments from municipality creating an improved sustainability beyond the project.

As previously described the *ActNow!* project provides a consistent methodology identifying capacity gaps for SEAP implementation in municipalities. The aim is to have an optimal and tailored capacity building scheme uncovering the identified obstacles. The methodology is also applicable for municipalities that would like to update their current SEAPs to SECAPs or even to municipalities that would like to create a new SECAP without having a SEAP.

The customised capacity building methodology is based on 2 main stages (see figure 40):

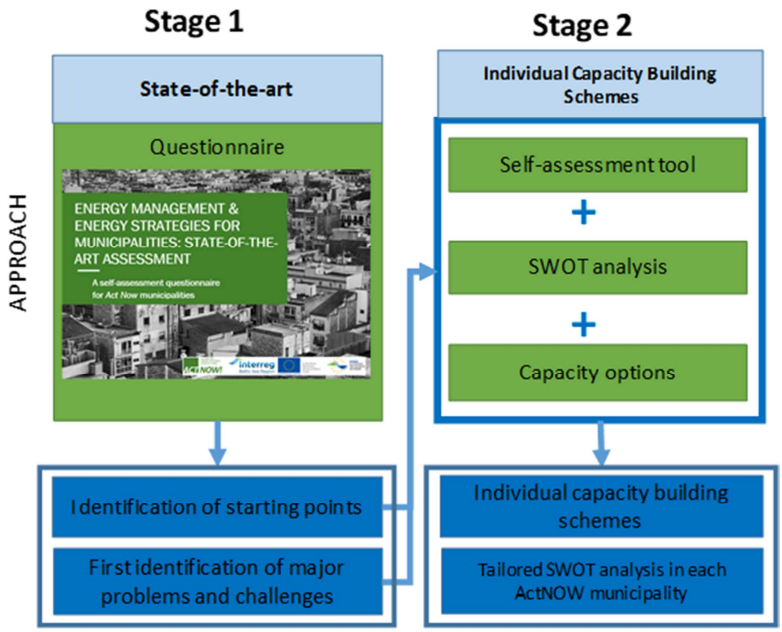


Figure 42. Customised capacity building methodology with 2 main stages.

The main elements characterizing each stage are:

- Stage 1. First identification of major problems and challenges in the Energy Management System (EnMS) and Energy Efficiency (EE) within the SEAP, SECAP or municipal energy plans. This task is fulfilled by the use of a specific questionnaire as a simple tool for the municipality to evaluate and understand their current situation, to identify areas of strength for building upon, and also to identify areas where improvement may be desirable or even necessary (See chapter 3.1 for further details, and the *ActNow!* learning platform for the actual questionnaire: actnow-baltic.eu/learning/tools);
- Stage 2. Identification of specific needs and gaps by implementing a SWOT analysis and a Multi Criteria Approach in quantitative self-assessment tool**.** These tools aim for identification of the potential key priorities for implementing a Capacity Building Scheme.

During this process several tools and approaches were developed according to the Guideline “Energy Efficiency for buildings” and Manual “from SEAP to investements”. All these materials are available in the

knowledge platform of the *ActNow!* in fact considered as web-based training programme addressed to local authorities outside the project partnership.

The specific pilot investments developed were mainly oriented on ICT based energy monitoring including Computer Aided Facility Management (CAFM) and/or installation of novel EnMS equipment.

According to the project description 3 main coaching expert partners (i.e. PP 7 - Centria; PP 10 - Szewalski Institute; PP 12, Riga Technical University) should create the interface among for the project partnership in order to:

- propose and develop software solutions for the processing of energy consumption data;
- introduce them into the project by making them available for the investing municipalities;
- eventually and possibly harmonize these tools and make them available for the whole project partnership.

PP12 (RTU) coordinate these task as a transnational workgroup concerning the investments.

The work share for expertise within the transnational value of experience form ActNow! pilot investments is shown in figure 41. and cooperation of partners for development of tailored solutions for pilots is shown in figure 42.

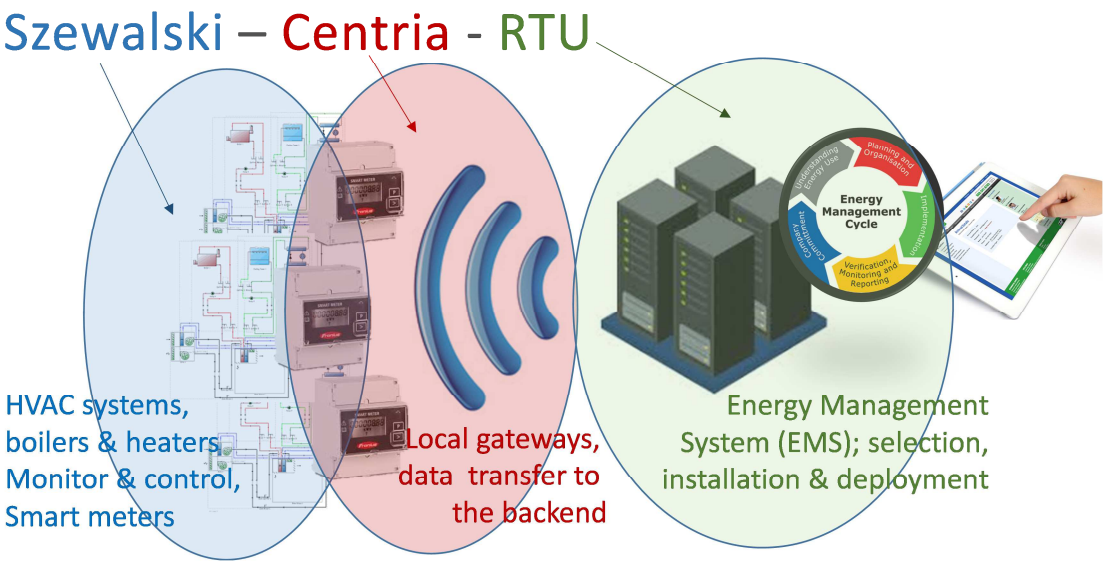


Figure 43. Work share for expertise ActNow! project.

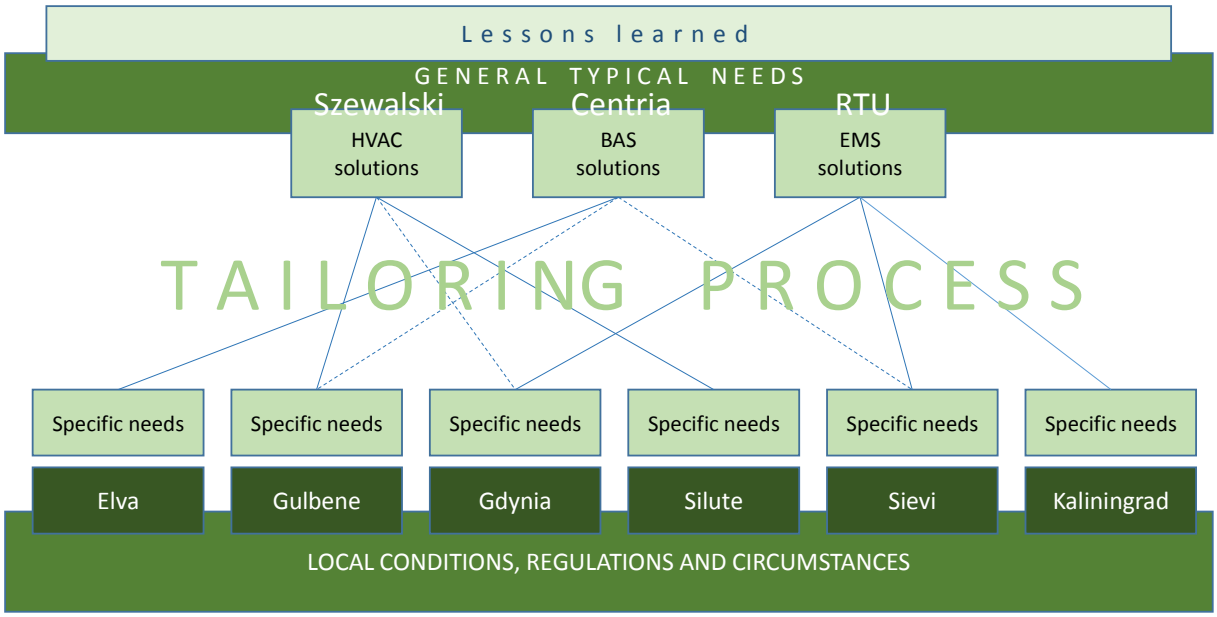


Figure 44. Cooperation of partners during ActNow! project.

The total budget assigned for pilots is 324 742€. The budget is split between participating partners in the pilot cases as shown in table 5.

Table 5. The budget assigned for every partner of the pilot.

Investing PP	**Coaching PP**	**HW&SW**	**installation**
Gdynia	Szewalski	14k+50k	1000
Silute	Civitta	50k	← incl.
Gulbene	RTU	42k+5k	
Elva	LETEK	50k	← incl.
Ylivieska	Centria	40k	10k
Kaliningrad	Imm.Kant.uni	25k+25k	4700

Figure 43 shows the investment coverage developed by each municipality at a glance. The transnational value is lying on considering the investment as “reference implementation” of tailored investment needed

and beneficial for a particular municipality. The conceptual framework, including the tandem approach and the tools developed within the capacity building scheme, represents a scheme applicable and deployable in other municipalities. This approach represents a proof-of-concept in terms of increased capacity and acquired technical knowledge in the municipality towards the implementation of more consistent and active energy management systems.

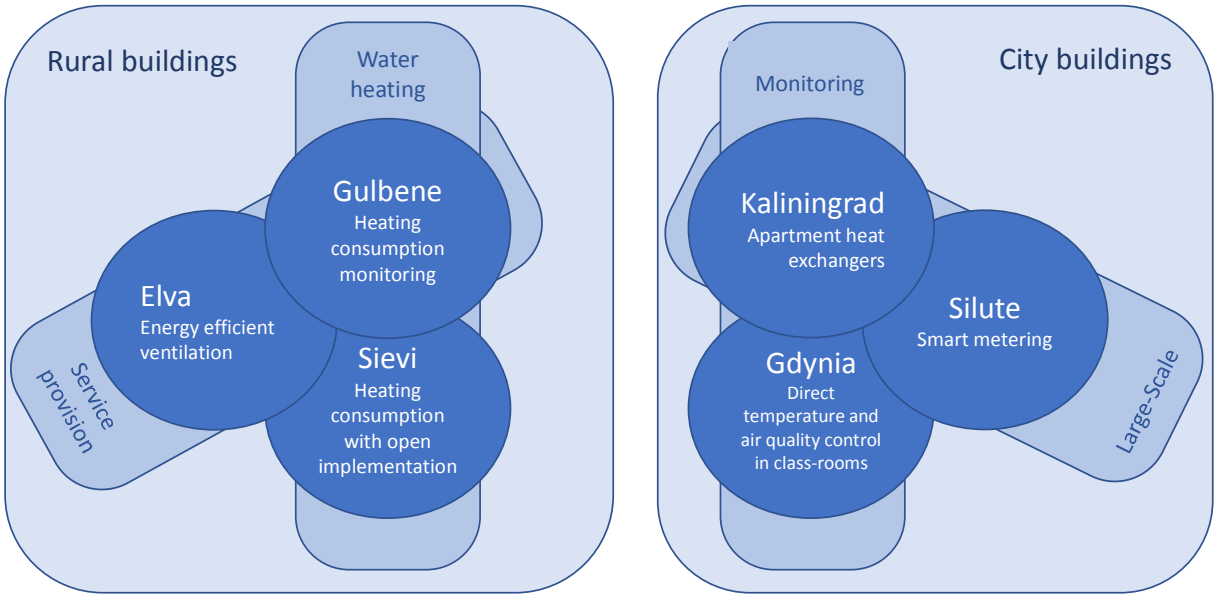


Figure 45. ActNow! investment coverage.

As one can see from figure 45 each tandem approach identified specific needs addressing different challenges as results of different perspectives implemented within the capacity building scheme.

In the project *ActNow!* two main focuses of the development of the Energy Management Systems were identifed:

- Urban areas: with an emphasis on municipal buildings;
- Rural areas: mostly addressed to improve the EnMS of municipal buildings in rural contexts.

The coaching expert Centria, Szewalski Institute and Riga Technical University proposed software and hardware solutions for processing of energy consumption data. This cooperation creates the framework to harmonize such tools and to make them available for the whole project partnership.

In particular RTU proposed the use of software implemented an energy management developed by RTU in cooperation with a private company (see figure 44).

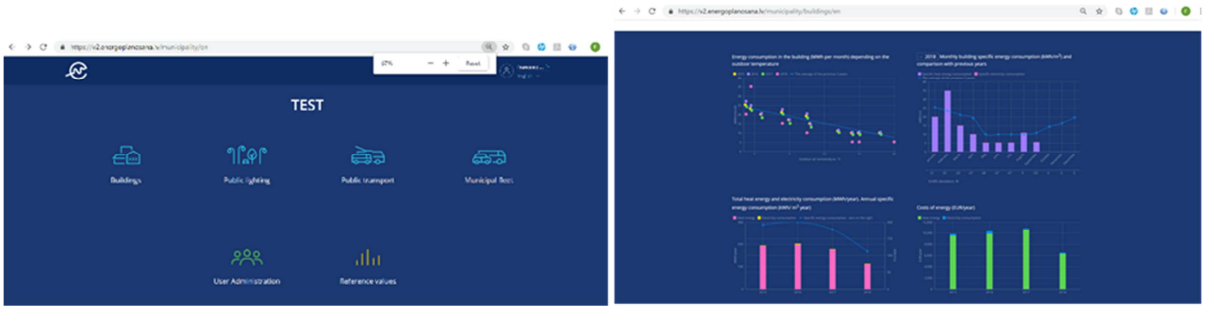


Figure 46. Tool "Energoplanosana".

The tool "Energoplanosana" (https://v2.energoplanosana.lv/municipality/buildings/en) was presented during the workshop about investment organized in the Gdynia project meeting on the 19th October 2018. The overall approach and the main benefits of the software were introduced, thus making them available for the investing municipalities and partnership. Two municipalities wanted to test the tool in their specific conditions.

PP 7 (Centria) investigated the situation both in Ylivieska region and in Sievi municipality, which was selected as a pilot commune in the region. As a result, Centria decided to act in two ways with the investment budget. Firstly, a diagnostic energy flow measurement set was acquired together with a weather station for providing actual outdoor condition information. This setup is easy to be deployed in non-intrusive way to whatever building with hot water-based heating system. It can both record the values for several weeks, measuring the energy flows in 4 individual circuits. This measurement set was used in several buildings in Sievi, and it will be available for the whole region also after the project.

Secondly, Sievi municipality needed help with including village schools to their building monitoring system. As typical, only bigger buildings had been renovated during earlier years, and then they were equipped also with modern building automation systems by a big multi-national service provider enterprise. As a result, smaller village schools further away still stayed without any remote monitoring or control with their heating system. Therefore, a universal set of energy consumption measurement devices were installed in six village schools. These devices are easy to be connected to the rest of building automation and energy management system framework of Sievi municipality.

PP 10 (IMP PAN) proposed to Gdynia modern online system for control of thermal and air-quality conditions to purchase. It was installed in a school building and tested – conclusions were presented during III National Workshop. Besides IMP PAN developed patent for modern ventilation system, which might be of special use during pandemic. Moreover, the innovative system for registering and sending to WEB cloud location the data from the metering devices mounted by energy/heat providers. The prototype system was tested and proved its potential.

The solution implemented made possible to evaluate effect related to air quality versus energy efficiency. There can be some cases when strong measures related to energy efficiency may negatively influence air quality in classrooms. The implemented pilot represent also a technical solution for a proper ventilation system to a potential decline COVID virus diffusion and effects.

The online system can be used as control systems when the heating/electricity data deviate from the benchmark. Lack of heat demand control may lead to overheating even during lockdown and holidays.

Reduction of heat supply during weekend and nights may bring even 30% savings. The analysis of the data collected has shown that a too low humidity in classrooms (even below 40%) may lead to health problems.

The proposed technology represents a possible replicable concept. Nevertheless, new technology implementation requires promotion, government support, courage and consequence in their advancement on the side of administration.

The transnational value of the output is given as proof of the concept for adapting energy management systems to the local needs and the harmonized implementation of the investments.

This approach is using the the Guideline "Energy Efficiency Strategy for Buildings" and the related web-based training mostly in terms of tailored Capacity Building Scheme as background material.

During the project meeting in Gdynia and Kalmar was discussed about the meaning of the transnational value within the implementation of the investment and the way how to connect and harmonize the GoA3.2 investment in the total investment plan. The main conclusions were the following.

A bottom-up and top-down approach should be followed in order to make possible a more effective knowledge transfer of the implemented investment in GoA3.2. The top-down approach should work on creating in the synergy to the local government with the experience gathered within the *ActNow!* Project implementation; while a bottom-up should be more focused on the real local need of a municipality. The transnational values from a bottom-up perspectives are reported in the next section with all the feedbacks received by each partner.

In order to connect and harmonize the GoA3.2 investment in the total investment plan the main role should be played by the CBS developed within each municipality.

5.1. Transnational value from Sievi municipality perspectives

Made investments act as a good reference implementation of the retro-fitted energy monitoring system in any rural area municipality in Europe. Largely the same obstacles and difficulties exist in communes in many countries, and the way they have been solved in Sievi case, can provide an encouraging way for implementation elsewhere as well.

5.2. Transnational value from Elva municipality perspectives

During the project exchange of knowledge with Latvian partners as the closest neighbours has been very helpful. Advantage of flexibility of choices in different partner municipalities allowed testing different measures and comparing their efficiency, which was very educative and useful and a major topic for discussions at the project meetings. The solution applied in Elva is quite unique and after some time of operation could serve as a motivating example for less experienced municipalities anywhere in the neighbourhood.

5.3. Transnational value Gulbene

Within the partnership the main lesson that partners could learn is that a remote data storage system can be set up at a relatively low cost because there are service providers in the market that sell cheap and at

the same time qualitative products. When high-quality data is collected, it is necessary to plan its high-quality processing, therefore entrust the work to automatic systems so that they analyse the data and present it to the user. It is hard to make an EnMS without SECAP where main goals have been set.

Outside the partnership the main lesson that other municipalities could learn from our experience is that problems need to be identified and goals set to overcome the problems. One of the biggest challenges is to collect data, there for it is better to use remote data recording systems. Another lesson is that Municipality needs to understand borders for SECAP and EnMS, because it is hard to make data analysis qualitatively if there are many buildings in Municipality with street lightning and car park.

5.4. Transnational value Šilute

Silute District Municipality investment and experience could be helpful for other less experienced municipalities when trying to understand how to start taking care of this topic.

More advanced project partners shared valuable experiences and examples in the area of energy efficiency. Also, transnational value is reduction of energy use and reduction of the CO_2 emissions to the atmosphere that connects all the people around the world.

5.5. Transnational value Gdynia

We believe that our system can be very valuable in any country facing the same problems with building that are neither modern nor energy efficient. During school-building auditing a serious problem with air-quality was faced. Children in old school building with inefficient ventilation might be exposed to very high concentration of CO2 which significantly reduce their educational efficiency and performance. Modern technologies are ready but their implementation needs promotion, courage and consequence in advancement. Very high potential in reduction of heat supply was discover in municipal school buildings.

A proper energy management system can help to reduce the heat supply significantly (more than 30%).

5.6. Transnational value Gdynia PKT

The outcome of the system installation in the trolleybus depot building in Gdynia has turned out to be better than originally expected, so this example of investment can be labelled as a „success story" and should be widely disseminated. As for the transnational value, the system is a perfect replicable example and flexible enough in is design so that after adaptation it can be easily implemented in other buildings, not only depot ones. As for now, the building of PKT depot in Gdynia serves as an EnMS implementation reference, a lighthouse and a best practice model for other buildings in the Pomorskie region and hopefully beyond. PKT is a municipal company owned by the City of Gdynia, so the experiences on EnMS gained in this municipality owned company may now be transferred to other buildings which are directly owned by the municipality. PKT is willing to share its experience on the system with any interested stakeholder.

5.7. Transnational value Kaliningrad

Value in the exchange of experience in the application and modernization of EnMS (application of standard energy-saving solutions, financial planning and ranking of EE measures, etc).

Comparing technical solutions on energy efficient measures between the *ActNow!* partners helped Kaliningrad LEEG to develop own approach and find the proper decision on pilot investment and financing mechanisms.

Improving the existing energy management system through the introduction of an automated energy management system with subsequent analysis of the results and development of EE measures - this experience can be transferred to any other country and municipality. The software was developed by the university and can be applied not only in the municipality administration but to any other organization.

6. Further steps

After *ActNow!* project further steps with application of the results of pilot cases for municipalities are considered.

6.1. Sievi

Encouraged by *ActNow!*, Sievi municipality is currently having an independent procurement negotiations with Schneider of their EnMS service, but at the time being, no results have been announced. However, completed *ActNow!* investment for the school buildings is designed so, that the connection to the possible SAAS service is easy to build, and initial survey for that has been made in order to guarantee easy realization of data exchange from Beckhoff system to another service provider later on.

6.2. Elva

With the budget available in *ActNow!* a pilot investment was made for the EnMS. It is a common understanding in the municipality that this has proven to be useful so after the project ends the municipality plans to develop the system further and extend it well beyond the five initial pilot sites.

6.3. Gulbene

The implemented system is expected to continue to exist after the end of the project. There are planned funds from the municipal budget to finance the operation and maintenance of the system. There is planned to add new objects to the system (car park, buildings and street lightning in parishes), because currently only Gulbene municipality buildings in Gulbene town and street lighting will be added.

6.4. Silute

The Municipality of Silute is always looking for ways to finance and implement energy efficiency measures in buildings, public transport, street lighting, including smart heat consumption management and monitoring system in the remaining public buildings and further – in private buildings.

As mentioned before, due to strengthened capacities of participating Municipality's employees, the application for the technical studies European energy efficiency fund (EEEF) was prepared and the grant received. Therefore, retrofit of 11 more public buildings (5 schools, 3 kindergartens, 1 cultural house, 1 hospital and building of the municipality) are being planned, energy audits and investment plans are being prepared.

6.5. Gdynia

The system undergone a long-time stability test to verify both the hardware and software layer. The measurement results database will be hosted by IMP PAN and it will be made available for all interested parties.

The recommendation for Gdynia municipality will be developed and provided.

The installed recorders are mobile, thanks to which, after the final analyses, the purchased equipment will be moved to the next selected facility. Monitoring in the Primary School No. 23 will be carried out for one whole heating period (1 year) that is until December 2020.

6.6. Gdynia PKT

By the possibility of archiving all the data and thus creating new patterns of setting particular parameters controlled by the system the new EnMS provides great opportunities for future energy savings which are estimated at 20%-30%.

Currently, the building manager is writing a manual for using the EnMS by other authorised persons, namely 6 shift managers of the workshop hall (partial access to the EnMS) and building conservators (full access to the EnMS). Thus, more employees in PKT will be instructed how to use the system effectively.

Also, PKT plans further dissemination of the investment results in order to recommend this EnMS solution on a larger scale.

Last but not least, PKT Gdynia depot EnMS system is by far not a closed investment – it may be further developed and expanded according to future challenges and needs.

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