Accelerating the Pace of Energy Efficiency by Improved Energy Audit Data Handling

Output result report:
WP2 Improving Energy Audits Capacity in BSR

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Documentation from the project can be found on https://trea.ee/cams

Executive summary

International experiences on a new methodology applied to energy audits and buildings energy performance certificates.

Energy efficiency is often described as the first fuel for the global economy, and in the recent years the pace for energy efficiency has decreased (IEA, 2019). Despite that EU has created Directives in order to address the efficiency challenges, e.g. EED (Energy Efficiency Directive, 2010/31/EU) or EPBD (2012/27/EU, Energy Performance for Buildings Directive), the trend is not promising. One powerful tool to identify efficiency potential is an energy audit, which intends to identify and propose measures on how to increase the energy efficiency in an object (building, industrial facility, etc.). The "Building Energy Performance Certificates" (BEPC) is a similar concept to audits, but only applied to buildings and are in general not as thorough as an energy audit.

Understandably, a great number of audits and BEPC are issued, and with them a lot of data is generated. This big data may provide a valuable information for many different stakeholders, e.g., regulatory and policy formulating bodies, the private sector, etc. However, no substantial efforts on collecting and analyze this data are being done, and in those cases that some efforts are made, no information or knowledge is derived from it. One key issue related to the collection of audit data is that is lacks uniformity and categorization, which makes information extraction both difficult and costly.

At the same time, digitalization provides a lot of opportunities in energy efficiency. In this project, a new methodology (the SPEEED-methodology) which utilizes digitalization for energy audits and BEPC has been developed and in practice implemented to enable the many benefits from improved energy data handling, e.g.:

- Highly increased cost-effectiveness of energy efficiency policies.
- Accelerating the pace for increased energy efficiency by establishment of e.g. a database which increase incentives for implementing efficiency measures.
- Continuously benchmarking of energy use, which brings insights for all stakeholders.
- Concrete ways for national authority to work proactive with multiple EU- Directives.

In practice, the methodology has been internationally implemented on 33 pilot energy audits within the Climate Adaptation and Mitigation Synergies (CAMS) project, which is a project part-financed by the Interreg Baltic Sea Region Program. Since the CAMS platform focuses on the housing sector, energy audits of buildings have been in focus for the methodology project. Beyond pilot audits, a status quo report regarding energy audits and BEPC was made and as well National Energy Audit days, in form of online lectures and follow-up surveys to national stakeholders, was held.

The participating project partners that have been involved in developing the methodology, conducting pilot energy audits, and formulating policy recommendations has been:

- Estonia: Tartu Regional Energy Agency
- Sweden: County Board of Dalarna
- Poland: Foundation for Energy Saving

- Latvia: Ministry of Economics
- Russia: Peter the great St. Petersburg Polytechnical University
- Nordic Energy Audit AB, Sweden: Area experts & contracted service provider.

Nordic Energy Audit AB were contracted to develop and implement the methodology and as well support the project with a digital platform accordingly to the methodology. The platform used to collect and structure audit data in the project is the Nordic Energy Audit Database (NEAD®).

The status quo report states that there are large discrepancies on how the concept of primarily energy audits, but as well BEPC, are incorporated nationally with different regulations and approaches. The auditor's competence is generally high, but more efforts are needed to address knowledge gaps in non-core business such as utilization of digital tools, economic calculations, etc.

Pilot audits were made in 5 countries, 12 regions and 19 municipalities, distributed among 4 NACE division, of which most were in sector L – real estate activities. In total, approximately 344 GWh and 65 000-ton CO_{2eq} were accounted for. In the following quality control, which was possible due to the methodology applied and the platform used, big discrepancies was found ranging from excellent quality to insufficient quality.

One important finding is that the most common proposed energy efficiency measures in the pilot audits, was the least cost-efficient for energy and CO_2 savings. In some cases, the most common proposed measures were up to 50 times more expensive than other, less common, proposed measures.

Based on the project results, some major conclusions are to be highlighted. Firstly, this project constitutes is a concrete Proof of Concept for how to improve energy audit methodology, utilize digitalization within energy efficiency and how to generate new key knowledge for e.g. policy design and evaluation. The utilization of digitalization in combination with a well-designed methodology within the area of energy efficiency, energy audits and BEPC would enable many benefits. Secondly, the pace of energy efficiency could increase if an improved central quality control of energy audits and BEPC are implemented in member countries. Furthermore, all project partners welcome stronger regulation and tougher implementation of Directives and more incentives for voluntary energy audits. Lastly, one possible outcome with improved handling of energy efficiency measures is to provide financial institutions with real proof that efficiency measures are profitable, which can increase the pace of green loans and thereby increased pace of energy efficiency.

All this brings to an understanding of the necessity of an integrated national and/or international energy audit database for energy efficiency end-use data and improvement opportunities. To realize the identified improvement opportunities in this report and as well as to address areas that were less covered in the project, the following two projects to be initiated in the future, are suggested by the project partners:

- A project focusing on implementing energy efficiency measure database(s).
- A common project on improving and harmonizing energy audit methodology and data handling.

Content

Background

40 % of the energy use in the EU is related to buildings and a large amount of the buildings are not renovated, leaving a huge untapped energy efficiency potential. The improvement of energy efficiency is one of the most cost-effective ways to concurrently improve the security of energy supply, reduce energy-related emissions, assure affordable energy prices, and improve economic competitiveness.

EU Directives on energy efficiency created a common framework of measures across Member States to ensure the achievement of the EU's 20% headline target on energy efficiency by 2020, and to pave the way for further energy efficiency improvements beyond this date. It aims to remove market barriers and failures and promotes a more efficient use of energy in supply and demand side applications.

One of the EU Directives, Directive 2010/31/EU, Energy Performance for Buildings Directive (EPBD) sets out a general framework for determining buildings' energy performance. It requires Member States to adopt long-term renovation strategies and establish a system of certification of the minimum energy performance requirements of newly constructed and existing buildings larger than 250 square meters, rented out or to be sold.

Directive 2018/844/EU is amending the EPBD that member states shall transpose to the national law at the latest in March 2020. The Directive aims to improve transparency of building energy performance certificates (BEPC) through including and orderly using required calculation parameters. It requires the performance of all technical building systems (space heating or cooling, etc.) are to be included in building certification and checked for compliance.

Buildings conclude a rather diverse and complex arena. It can be private and publicly owned, for either private or public use and serve for many different purposes, e g: housing, offices, schools, sports, shops, religious activity, industry etc.

To meet the regulations for BEPC covered by the EPBD, it is necessary to perform an energy audit which is a proven tool for analysing energy use and identifying energy efficiency improvement opportunities in buildings and companies. The key components of an energy audit are:

- Collecting existing data and conducting additional measurements as a part of an instrumental survey of the object.
- Analysing building and utility data, including study of the installed equipment and analysis of energy costs.
- Analysing real operating conditions.
- Understanding of building behaviour and interactions with weather, occupancy, and operating schedules.
- Selecting and evaluating of energy saving measures.
- Estimating energy saving potential.

Energy audits of buildings are less costly than audits of industrial facilities, but the energy efficiency measures proposed in buildings are generally investment intensive and have a higher payback period.

Two major standards for energy audits exists: the ISO 50002 and the European standard EN 16247. However, despite the existence of standards, no clear guidelines on methodology are available which result in major challenges to analyse and harmonize results on a large scale. Another result of the absence of methodology guidelines is the lack of quality control of an audit, resulting in significantly different audit qualities, both domestically and internationally. Since the quality is allowed to differ, auditors/firms with the lowest prices, and most often quality, wins procurements/contracts.

The rationality of how an audit is done needs to be increased since both quality and approaches differs. A common methodology for energy audits among EU-countries may solve imminent challenges, but some important added values are created at the same time. One aspect is that much energy-related data is generated during energy audits but for the time being, this data is not analysed on a broader scale. The results of energy audits are not being used pragmatically and get lost remaining at the customer. In fact, uniform collection and analysis of this information could result in a bottom-up approach for handling energy and environmental data which could highly contribute to more strategic work against Agenda 2030.

Another aspect is that the pace of energy audits needs to be accelerated, since it is one of the strongest tools for identifying and improving energy efficiency potential. This would be possible if findings and learnings from energy audits are stored, analysed, and processed over time. Therefore, a necessity for energy-related data handling seems to be an obvious bringing to a concept of a database for energy efficiency end-use data and improvement opportunities.

This opens up an important research gap. A lot of research is being done in a field of rapid development of high-intelligent modern technologies, however, there is no study showing possibilities of utilizing and reproducing the prominent amount of energy data generated, among other things, through energy audits.

Due to these reasons, a unique study is presented in this paper, showing the opportunities of implementing a unified methodology for energy audit data handling. Furthermore, there is no study being performed on comparison of energy audit processes in buildings among different countries. Overall, the international data for buildings is scarce. However, this is a very compelling topic due to differences in standards, legislative frameworks, and methods of performing energy audits in different countries.

The present study can address the following aspects and benefits:

- By developing and implementing a unified methodology for energy audit, the basis for data analysis and benchmarking is being set.
- By developing a database for collection of unified and quality-controlled data, analysis and benchmarking become possible on a process, building, sector, and regional level.
- By training in a audit methodology, carrying out multiple energy audits and analysing data from the database, the competence among energy auditors can be increased. Furthermore, by using a unified methodology, the quality of audits (reports and recommendations) will be increased.
- By analysing results from multiple audits in the database, new knowledge will be created that could inspire new actions and innovations targeting energy efficiency.

- By transnational cooperation, experience exchange and mutual learning, energy auditing could be further improved, and multilingual barriers eliminated.
- By using the unified methodology, shorter time for conducting energy audits may be achieved. Also, implementation of large-scale investments in energy audits of higher quality could also probably be conducted at lower costs.
- By applying findings from the project to development of policy recommendations, it could be possible to contribute to forming relevant future policies and guidelines as well as to evaluation of current and former ones.

Purpose and aim

The purpose with this project is to define and in practice apply a common methodology for the concept of energy audits, with focus on the following:

- Clear specification of requested datapoints from an audit.
- Implementing a quality control structure of audits.
- Enabling benchmarking and establishing baselines.
- Collecting, analysing, and quantifying proposed energy efficiency measures from audits.

Preferable is also if BEPC can be included in the methodology scope.

If the project is regarded as successful, it represents a Proof of Concept for how to improve audit methodology and energy data handling in a national context. However, in a broader perspective, the ambition with the project is to initiate a common knowledge platform within the EU.

The aim of the project is to decide if the methodology can be further implemented on a large scale and enable the benefits of it.

Project partners & the CAMS project

The methodology has been applied within the CAMS platform[1] (Climate Adaptation & Mitigation Synergies), which is a project part-financed by the Interreg Baltic Sea Region Programme 2014-2020, Priority 2 "Natural resources", Specific objective 2.3 "Energy efficiency and aims to "Advancing the energy auditing, the qualification programme of housing renovation and policy dialogue for mitigation and adaptation synergies in housing renovations and service sector".

The participating partners who have been conducting pilot energy audits and developing the methodology are:

- Estonia: Tartu Regional Energy Agency
- Sweden: County Board of Dalarna
- Poland: Foundation for Energy Saving
- Latvia: Ministry of Economics
- Russia: Peter the great St. Petersburg Polytechnical University
- Nordic Energy Audit AB, Sweden

A service provider, Nordic Energy Audit AB (Sweden), has been contracted to develop and implement the methodology and as well support the project with a digital platform to facilitate the work. The platform used to collect and structure audit data in the project is the Nordic Energy Audit Database, NEAD®[2].

Since the CAMS platform focuses on the housing sector, energy audits of buildings and BEPC have been in focus for the project.

[1] CAMS website: https://projects.interreg-baltic.eu/projects/cams-platform-207.html
[2] For more information on the NEAD® software, please visit: https://www.nordicenergyaudit.se/

Literature study

A literature study has been performed showing the present findings within the area of building energy efficiency and end use data.

According to the comparative meta-analysis of residential green building policies and measures in the EU (Jabour, 2020), the recent increasing trends of electricity demand within the EU's residential sector have been offset by different energy efficiency policies. Among those are energy efficiency directives, targeted subsidies, monetary tools and incentives, energy supplier obligations, high-performance design, energy labelling, energy performance benchmarks and metrics, and educational campaigns (EC, 2021). The policies embrace legislative, financial, new market-based, informational, training, educational, co-operative, and cross-cutting measures. Many of those focus on behavioural patterns (Jabour, 2020). Also, country-specific action plans (National Energy Efficiency Action Plans) serve as a support mechanism for respective country to promote measures for improving energy efficiency.

Energy audits is a type of energy efficiency policy helping to overcome international barriers (Paramonova & Thollander, 2016). An audit itself does not bring energy efficiency improvement opportunities, however, the improvement opportunities can become obvious with its help (Backlund & Thollander, 2014). An energy audit can be a stand-alone policy programme or a part of a wider programme, for example a voluntary agreement. A comprehensive review of different energy audit programmes was conducted (Price & Lu, 2011).

The fact that the EU's policies and initiatives have a systematic and comprehensive character resulted in 30% energy-related residential energy savings during 2000-2016, which is equivalent to 100 Mtoe CO_2 (Jabour, 2020). The study shows that this character of the EU's policies could enable an international comparison. However, it only includes such statistics as overall energy and electricity use of residential sector per country, per dwelling and per m^2 area for respective countries as well as total energy savings per country. Another analysis of energy use trends in residential sector on the EU level shows as well only a level of energy data aggregation per country and m^2 area (Tzerianaki et al., 2019). The study suggested performing further analysis of energy use trends focusing on end-uses processes such as space heating and cooling, lighting, etc.

A survey of recommender systems for energy efficiency in buildings (Himeur et al., 2021) presents a recent tendency of development of modern technologies for data collection, aggregation and handling, such as internet of things and artificial intelligence (AI) technologies. The study points out that a wider use of latest technologies could affect positively individuals' energy saving awareness, behavioural patterns and attitudes. For that purpose, so called context-aware recommender systems can be applied which embrace AI, analysis of behavioural patterns, and decision-making by an individual. Recommender systems can be divided in several groups of technologies each focusing on such aspects as "high-performance" buildings (Taherahmadi, 2020), intelligent systems for monitoring (Boodi, 2018), and recommendation algorithms. Despite the immense number of tools and techniques available on the market, there are many challenges associated with its implementation, i.e. difficulties with its commercialization, lack of data for analysis and benchmark datasets (Jain et al., 2020), as well as difficulties of data reproducibility (Drachsler et al., 2010; Dacrema et al., 2019).

Thus, even though the deployment of smart-meters, sensors, monitoring, and visualisation techniques seems widespread and promising, there is an important point missing. Huge energy-related datasets require to be stored, unified, and processed in such way that it can be accessible to different users and bolster energy efficiency assessment and improvement.

The study by (Blomqvist & Thollander, 2015) brings up an importance of an integrated dataset for energy efficiency end-use data and improvement opportunities. This kind of dataset shall support energy specialists, auditors, and end-users to overcome energy-related informational barriers. The dataset used in this study is unique in a sense that it comprises different data sources from different countries. There are several world-wide efforts for gathering energy data, however, one general issue with existing databases is that the data within them usually is aggregated on a high level. This does not enable comparison on organisational and process levels.

Another important issue that arises when dealing with energy data is that there are different taxonomies, units, and formatting used in different countries, regions, and organisations which makes it hard to compare (Blomqvist & Thollander, 2015). This also proves an importance of creating such energy-related dataset that would combine standardised open data and make it available to different users. As one example, this would simplify a process of energy audit and make it firmer and more standardized. Another example is a complete mapping among different organisations, sectors, and countries with a possibility to downplay a multilingual issue.

Method

Project workflow

The project has been conducted accordingly to Figure 1.

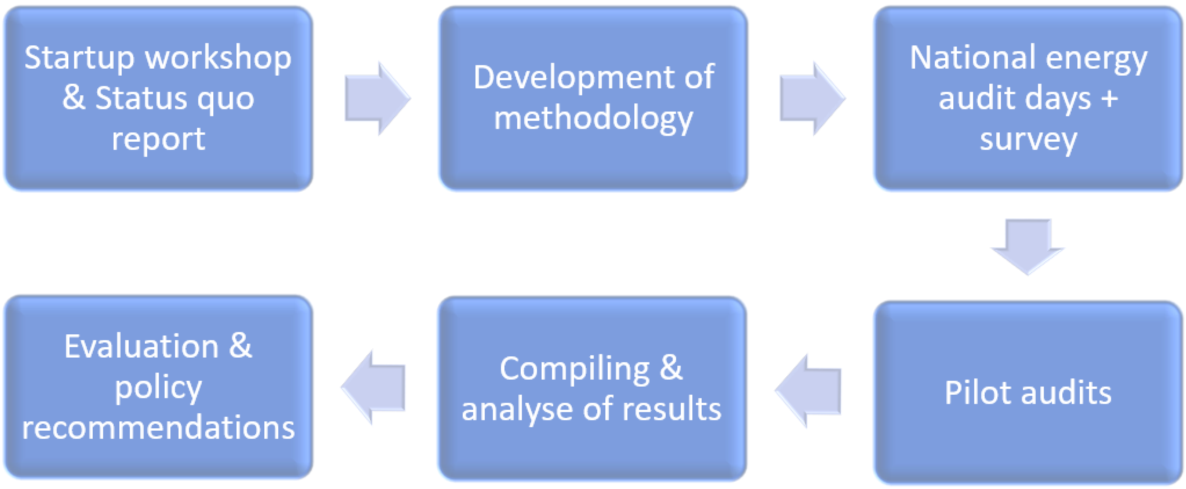

Figure 1, project workflow.

The start-up workshop & Status quo report intended to map the current energy auditing and BEPC situation in each partner country and introduce the stakeholders to the project plan. The time between the introduction workshop and national energy audit days was used to adjust the methodology based on the status quo report findings. The national energy audit days' preliminary plan was to meet each stakeholder in their respective country, but the COVID-19 situation changed the planning, and the meetings were rearranged to online format with lectures on the developed methodology and state-of-the-art on energy auditing. Thereafter, 33 pilot audits were initiated, finished and reported. The aftermath of the audits was to compile and analyse the results, which is thoroughly accounted for in the Results chapter. Based on the results, policy formulations on the topic were stated by the project as such and as well for every participating partner nation.

SPEEED -methodology

To approach the challenges stated, the so called "SPEEED"- methodology (Sector specific Process for Excellent Energy Efficiency Data handling) has been developed and implemented. It consists of five key components, see Figure 2.

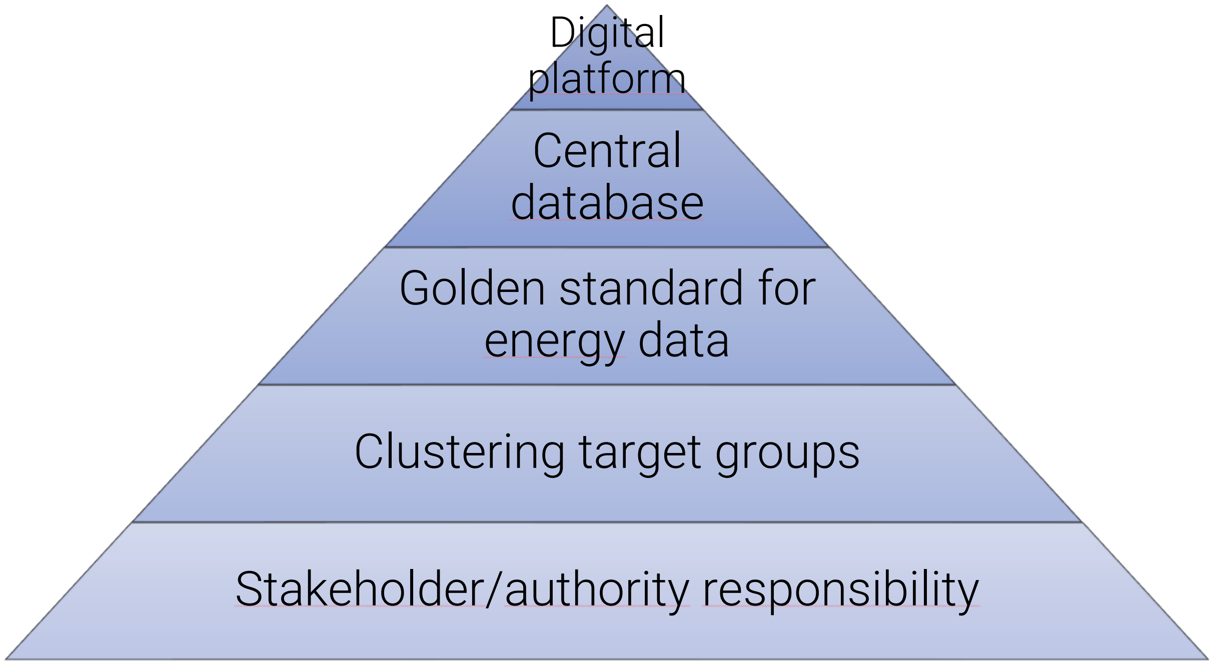

Figure 2, the SPEEED methodology key components

In the sections below, the different key components are elaborated on:

Stakeholder responsibility

Since audits may be conducted in many contexts, some governmental responsibility is needed to incorporate the methodology continuously. In the project, every participating partner have accounted for which national stakeholders that is involved in the process of an energy audits and in which way. For a list of stakeholders involved in the project and/or identified as relevant for the methodology implementation, see Annex 1.

Clustering target groups

Audits is being performed in every economic sector, which makes it a broad tool in the chase for increasing energy efficiency. However, an audit has different focus areas depending on which sectors they are applied to. For example, in the residential sector, much of the energy use is on space heating and cooling, while for many industrial sectors, space heating and cooling stands for relatively small part of the energy usage. Furthermore, some end-use categories cannot be applied everywhere, which makes clustering of target groups important. The SPEEED methodology therefore uses an overarching clustering of audits based on EU:s NACE- codes.

Golden standard for energy data

Both energy audits and energy data exist in many contexts, and auditors most often have their own way of accounting for energy use. Some guidelines on how to account is presented in the existing standards, but no explicit demands. For each audit, this is not an issue, since the purpose can be fulfilled, but quantitative analyzes is very difficult and time demanding without data harmonization. Therefore, a specific dataset - a so called “golden standard” - for what information an audit must contain is used. The golden standard aims on unifying audits in all economic sectors, but with unique data subsets for different sectors. This overarching "Golden standard" is described in Annex 2.

Central Database

Since the collection and structuring of data is central in the SPEEED methodology, a database that can be used continuously is needed. In this project the NEAD® software has been used, which is provided by the Swedish company Nordic Energy Audit AB. NEAD® consists of two databases, one on energy end-use, and one for energy efficiency measures. In addition, the NEAD® database on energy efficiency measures is paired/linked with EU Best Available Techniques reference documents (BREFs).

Digital platform

To in practice be able to work with the methodology, a digital platform is needed to act as a bridge between practice and data handling. It is also important that the digital platform can be used by many stakeholders for many different purposes, not only as a reporting portal (hence the labeling of platform and not portal). Since NEAD® as a concept constitutes a digital platform, it has been used in the project for data handling, quality control, visualization, and analyses. See Figure 3 for a schematic description of the setup.

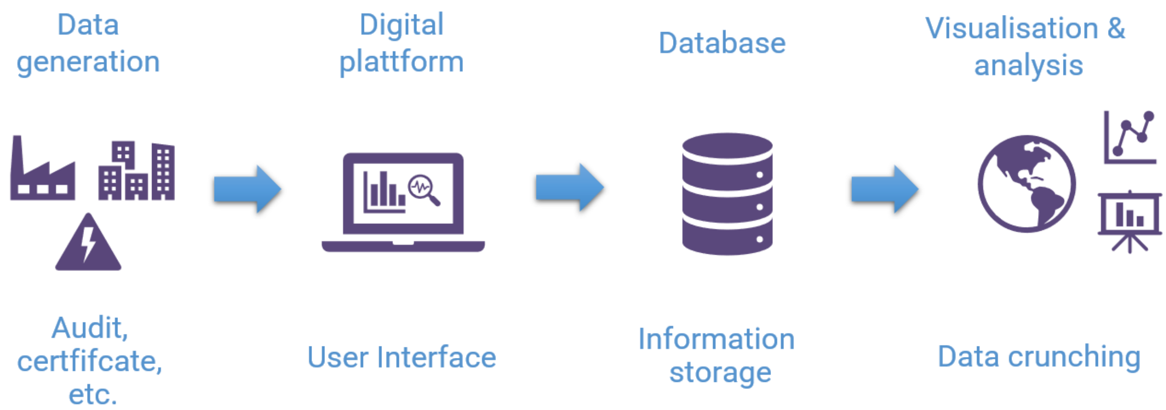

Figure 3, a schematic description of the digital setup.

National Energy Audit days

As a complement to the SPEEED methodology, the National Energy Auditing days were held, which intended to introduce the partner countries to the methodology and present "state of the art" within energy auditing. Furthermore, to investigate stakeholders' posture to using digital tools in the energy audit context, a complementary survey with experts from each partner country was arranged. The survey, which can be find in Annex 2, was categorized in two major sections:

1. Challenges with energy auditing
2. Digital tools and energy efficiency

Other project activities

Other project activities have been:

- Individual partner meetings which intended to contribute to the status quo report and support the participating partners on how to use the methodology and the NEAD® platform.
- Common and individual policy formulating meetings.
- Evaluations on the used software.

Results

Current circumstances in partner countries

In this part, the findings from the initial status quo report and the start-up workshop are shown briefly. The present conditions of BEPC and characteristics of energy audits in participating countries are provided in Table 1 and Table 2 correspondingly.

Table 1, resent conditions of BEPC in project partner countries, including Germany.

<table>
<tr><th>Member country</th><th>Responsible authorities</th><th>Responsibilities</th><th>Energy certification</th></tr>
<tr><td>Estonia</td><td>Ministry of Economic Affairs and Communications</td><td>Energy certification, auditing and implementation of energy saving measures</td><td rowspan="9">BEPC is required for buildings that are new, if the building is larger than 250 square meters, if it is rented out and if the building will be sold.</td></tr>
<tr><td>Latvia</td><td>Ministry of Economics</td><td>All responsibilities</td></tr>
<tr><td>Poland</td><td>Ministry of Development</td><td>EPBD and EED directive</td></tr>
<tr><td rowspan="2">Germany</td><td>The Federal Ministry of the Interior, Building and Community</td><td>EPBD and EED</td></tr>
<tr><td>The Federal Office for Economic Affairs and Export Control</td><td>Checking EA</td></tr>
<tr><td rowspan="3">Sweden</td><td>the National Board of Housing, Building and Planning</td><td>EPBD</td></tr>
<tr><td>The Swedish Energy Agency</td><td>EED</td></tr>
<tr><td>Ministry of Enterprise and Innovation, The Swedish Energy Agency</td><td>Supervisory authorities</td></tr>
<tr></tr>
<tr><td>Russia</td><td>Ministry of Energy</td><td>Developing state policy and legal regulations in energy efficiency, EA and implementing measures.</td><td>The term “BEPC” for buildings is not used. The closest in meaning is the term “energy passport” which is a document that contains results of EA level I. It is obligatory for new buildings, multi-apartment buildings before retrofit with the state subsidies and for organizations that produce heat energy or pay more than 50 million RU/year energy costs.

A special case of benchmarking are BEPC containing integrated energy data of an object (EA level 0). Energy declaration are obligatory for all organizations with the state, regional or municipal property which pay less than 50 million RU/year</td></tr>
</table>

			energy costs and do not produce heat energy.

Table 2, characteristics of energy audits in project partner countries, including Germany.

<table>
<tr><th>Member country</th><th>Energy audit (EA) requirement</th><th>Scale of energy audit (EA)</th><th>Support instruments</th></tr>
<tr><td>Estonia</td><td rowspan="5">Only large companies and companies with large energy must do EA every 4 years (EU directives). Exemption is using a certified energy management system and, in some countries, less than 500 MWh/year energy use.</td><td>260 companies are obligated to do EA by 2020. 500 EA have been done during 2014-2020 and over 800 before. Most of EAs have been done in housing (apartment associations) and public sector (public buildings).</td><td>Grants for housing cooperatives (15-40 % of cost).

Feasibility and EA should be covered by applicant to get public co-financing to investments.</td></tr>
<tr><td>Latvia</td><td>45% of target group (large enterprises and enterprises with large electricity use (mostly SMEs)) has made EA (506 EA). Part of target group has introduced certified energy management system instead. Most EA have been done in manufacturing companies.</td><td>State owned ALTUM offers grant up to 85% of the cost of EA given that energy efficiency investments must be at least 25 times greater than the grant.</td></tr>
<tr><td>Poland</td><td>94,8 % of all large companies has done EA (3 379 EA), no data in SMEs. During 1999-2018 ca 45000 EA were made for thermal renovation projects, led mostly by housing cooperatives. Ca 75 % of all EAs is done for housing actors, including owners of small houses, and for local authorities as partners in EU co-financed projects and other institutions delivering public services. No reliable data for other types of EA and very few EA are done in business sector.</td><td>Financial benefits that only can be obtained if a building owner has EA, ex. finance from the Thermal Refurbishment Fund or in case of some other public co-financing from the EU.</td></tr>
<tr><td>Germany</td><td>N.A</td><td>The BAFA supports private households, municipalities and businesses and offers publications, consultations, and possibilities for exchange, such as specific events.</td></tr>
<tr><td>Sweden</td><td>1081 energy audits for large companies have been made and ca 1300 energy audits in small and medium size enterprises.</td><td>A program by the Swedish Energy Agency - 50% grants for EA and Environmental studies.

Several projects by the Swedish Energy Agency helping all sizes of enterprises to do EAs through subsidies, guidance, energy networks, but only SME can obtain financial support.</td></tr>
</table>

Russia	EA level 2 is voluntary. EA for dwellings is required when the building is prepared for renovation with financing from the state Overhaul Fund. Organizations whose energy use is less than 50 mln RU/year are not required to do an EA, but submit declaration.	The main customers for EA are industrial companies and organizations responsible for management of multi-flat buildings (a homeowners' partnership/a cooperative or a managing company with corresponding licence). When a building is prepared for renovation with financing from the state Overhaul Fund, these organizations must order EA. Since the state retrofit program started recently, relatively small number of EAs have been done for multi-flat buildings. BEPC are done in a more simplified way than EA. Since it is a directive with requirements for certain type of buildings, statistics on how many BEPC that have been issued often exists.	EA is a condition for getting state subsidy for retrofit projects.

Capacity & competence among energy auditors

All partner countries except Poland have regulations declaring that energy audits should be performed by certified professionals. If a company have an ISO 50001 or ISO 140001 certification, they can perform the energy audit by themselves.

Estonia has 8 levels of competence for energy auditor. For large companies they should be qualified for level 8, for auditing in buildings at least level 6. The Qualifications Framework is governed by the Professions Act. In Estonia there is a total of 60 auditors of which 30 are active.

In almost all cases energy auditors comes from the private sector, both for energy audits and BEPC. In Russia energy auditors are members of a Self-Regulated Organization for auditors. In Estonia, a lot of energy auditors belong to Estonian Society of Heating and Ventilation Engineers, but there is no special association for energy auditors. In Poland there is an Association of Energy Auditors on voluntary principle with about 500 members. The association keeps the List of Recommended Auditors, with the names and contact details of auditors who have already carried at least 3 verified audits (currently about 240 auditors are on the list).

All partner countries testify that the competence is generally not high enough. For most partner countries there is not a system for quality control of auditors. In Estonia and Latvia, certifications must be renewed every 4-5 years. In Latvia energy auditor companies, which conducts energy audits in large enterprises, must be accredited, while BEPC are issued by individual certified persons. In Sweden, the competence is higher among individuals doing energy audits than BEPC.

It is common with a lack of understanding and knowledge in system perspective. Many auditors have a background in one technical field and have less competence in other areas. Since it can be hard to reach for all type of buildings/business sectors, auditors might need to specialize in some sectors. Collecting and providing data from previous energy audits can inspire auditor and support them in finding more possible measures, in this case, an example is the NEAD® platform which currently possess a database of energy efficiency measures and the corresponding connection to the BREF documents (BAT measure section in figure), Figure 4.

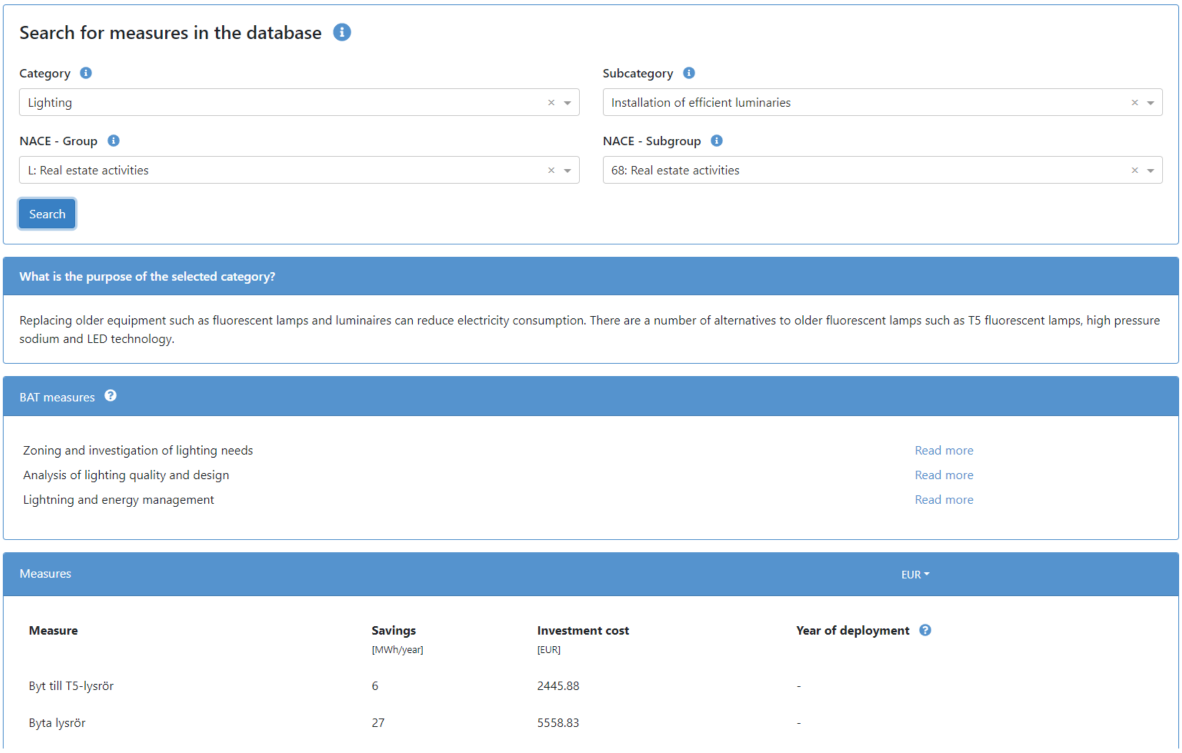

Figure 4, an example of an energy efficiency database. NEAD® screenshot.

Another competence that many times is lacking is the knowledge in correct metering. Many auditors do not do real measurements, but rather estimate the energy use for different end-use categories.

Quality of energy audits

The method for doing an energy audit is basically the same for all type of buildings in all partner countries; to map energy supply, distribute the energy to end-user as well as map, calculate and present possible measures.

In all partner countries there are guidelines setting the standard for what data should be included in an energy audit. Sweden have more detailed guidelines for different sectors and Estonia has specific guidelines for housing sector. General statements of the quality of energy audits are difficult to do, not least because variations can be significant. In Sweden, the evaluation of the former national energy audit program showed that a majority of 500 energy audits lacked high quality data. Many times, basic data was missing at the same time as it was obvious that data for energy use and measures just did not match. Audits financed by grants from the National Energy Agency have some basic control, but without specific competence within the field of energy data handling it is difficult for the authority to identify failures. Audits for obtaining BEPC hold a significant lower quality compared to real energy audits and quality control of BEPC and proposed measures are not being done.

In Estonia, the average qualification of energy auditors is good, but there have been a few complaints from contracting authorities and the quality level of BEPC varies. In 2014, a survey revealed that half of certifications remained below the high-quality mark. The status improved due to the digital processing of energy labels and since the Building Register acts as the basis of the data, it enables a certain quality control. If the auditor submits erroneous or false information, the registry will not verify the data and BEPC submission. Some BEPC, particularly in energy-intensive premises and buildings, may contain errors. The quality of energy certification and labelling is monitored and inspected by the Consumer Protection and Technical Regulatory Authority.

In Latvia BEPC can only be issued by certified experts. Assessment of their competence and monitoring of professional activity is ensured by independent authority, which promotes quality of BEPC.

In Russia, there is a need to improve qualifications of auditors for conducting serious audits for development and implementation of real energy conservation programs. BEPC (energy passports in Russian context) must be issued by professional auditors but energy declarations (since it is done at a very general level, with lacking degree of details) may be developed not involving professional auditors.

In Poland, the quality of energy audits is generally good, but not all are at the satisfactory level. There are great needs to improve the quality of BEPC and as well their broader use.

Data from BEPC are being collected in some way or another in all partner countries. In Sweden, data is registered in a national database managed by National board of housing and spatial planning, but there is not possible to aggregate data and to benchmark. Only single BEPC can be extracted from the database, which is the general case for all partner countries.

Type of energy data

In general, there is an absence of clear guidelines on how to account for energy data in energy audits. For example, the transposing of article 8 in EED looks different between EU member states (Nabitz & Hirzel, 2019). For example, the minimum coverage (i.e. what to account for) of energy audits in large companies is different between countries, where e.g., Swedish audits must have an "Representative" coverage where the energy usage is divided into three main categories: buildings, process, and transports. Other countries have other definitions which all in all leaves room for interpretation for both energy auditors and the companies of what an audit should account for (Nabitz & Hirzel, 2019).

Germany and Latvia have guidelines for standardization of energy end users. In Latvia standardization of energy end use is set in Cabinet regulations for both – buildings and enterprises. Estonia and Russia do not have any state standards for this, but in Russia members of the Self-Regulated Organization for auditors have developed internal standards which define details of auditing procedures and requirements to their outputs. In Poland, the standard methodology for Energy auditing is specified by the Governmental regulation.

Distributing energy use into specific standardized categories brings added value to energy auditing, since it enables possibilities for benchmarking and generation of valuable data that can be scaled up to generate new knowledge and energy efficiency support schemes. A standard for this has been developed in Sweden, based on international experience; see Thollander et al. 2015 for information about some country's way of categorizing energy end-use data for SMEs. Standard units used are:

- Space heating
- Space cooling
- Ventilation
- Lighting
- Compressed air
- Pumping
- Tap hot water
- Internal transports
- Administration
- Other.

Categorization of energy use can be done on different levels, see Figure 5.

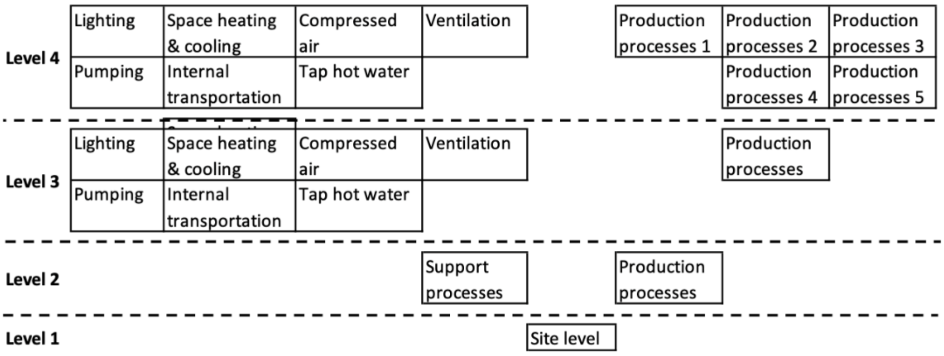

Figure 5, categorization of energy use by different levels (In Thollander et al., 2020, based on Arfwidsson and Andersson, 2016).

Currently, categorization of energy use is in general on level 1, even though some deeper categorisation is being done. However, without a harmonized standard on how to categorize energy end-use, an EU Member State and as well as the EU, can never gain knowledge on where the major energy end-use is found. Consequently, follow-up on where major progress is being made over the years and as well as to identify major gaps where improvements are too slow, cannot be distinguished.

Data collection and evaluation

In Germany, Estonia, and Russia there is no centralized collection of data from energy audits. In Estonia, the data on BEPC is collected in the Building Register, which currently is under development. For now, there is no benchmarking, categorization, or regional filtering possible. In Poland there is a central register without open access for more than 330 certain categories of public authority buildings.

In Latvia, there is a public portal, the building information system (BIS) managed by the State Construction Control Bureau, however it is not fully accessible. At the moment the BIS includes eight registers including a register for BEPC, a register of Energy Auditors of Enterprises (from year 2020) and a register of Energy Reports of Enterprises (from year 2020). The BIS ensures information exchange among the persons participating in the construction process; however, it does not provide additional functionalities to view, filter, sort, and group the data. Anyone can access an BEPC for a specific building one at a time. The BEPC show general information such as the building's energy performance by individual consumption positions, primary energy assessment, CO_2 assessment, etc. Other additional documents are also available to the registered users (experts performing certification), e.g., reports on economically justified energy efficiency improvement measures, input data used in the calculations, etc.

In Sweden audits financed with state grants are being reported into a database owned by the National Energy Agency, however the data quality is not controlled and there is no access for others to the database to take part of the results. Pilot studies have been done in developing a national database with quality-controlled data for analysis and benchmarking.

In Russia, the analytical portal is located at the official website of the Ministry of Energy with the following abilities: viewing pre-configured reports on main energy efficiency characteristics of the budget sector in the context of federal districts, constituent entities, municipal districts; formation of arbitrary analytical reports with parameters selected by users with an ability to automatically draw graphs based on them; searching and viewing BEPC/passports of individual institutions with an ability to view the characteristics of buildings. Currently, this portal is under construction and access is not available.

The system with BEPC or energy passports has not been evaluated in any of partner countries, in terms of energy saving effects. A common opinion in Sweden is that it has not provide very much energy savings and that BEPC are too shallow to meet the needs for energy and climate transformation. In Russia, there is a lot of criticism to the fact that mandatory energy audits were replaced by energy declarations due to lack of effects from declarations.

Overall, even if countries have responsible authorities for implemented the EU directive and have developed national policies for energy efficiency, a clear responsibility for actual implementing energy audit programs in large scale and measures is lacking. For this a more centralized approach is needed.

There is a lack of policy and support schemes that actual meet the need of energy auditing in a larger scale than today. Partners in the project welcome stronger regulation and tougher implementation of the directives as well as more incentives for voluntary energy audits. All entities should have an action plan on energy efficiency and transition to renewables. In countries without specialised institutions and national energy agencies, the motivation and capacity to develop well designed energy efficiency programs are not as strong as in countries who has those kinds of institutions.

The analysis also shows that there is a lack of control of the quality of energy audits as well as the BEPC. It is also hard to verify whether BEPC and energy audits have been performed by everyone that require to have them.

There is a great untapped potential in collecting data from energy audits in a uniform and standardized way in the Baltic Sea Region. The handling of all reported audits afterwards is non-existent, which is a problem that should be handled in a centralized way by the authorities rather than by a single energy auditors.

Pilot energy audits

In total, 33 audits with the applied methodology were registered in the project. The audits are distributed over 5 countries: 7 in Sweden, 5 in Russia, 6 in Poland, 8 in Latvia, 7 in Estonia. 12 regions and 19 municipalities are represented. 4 NACE divisions were registered, see Figure 6.

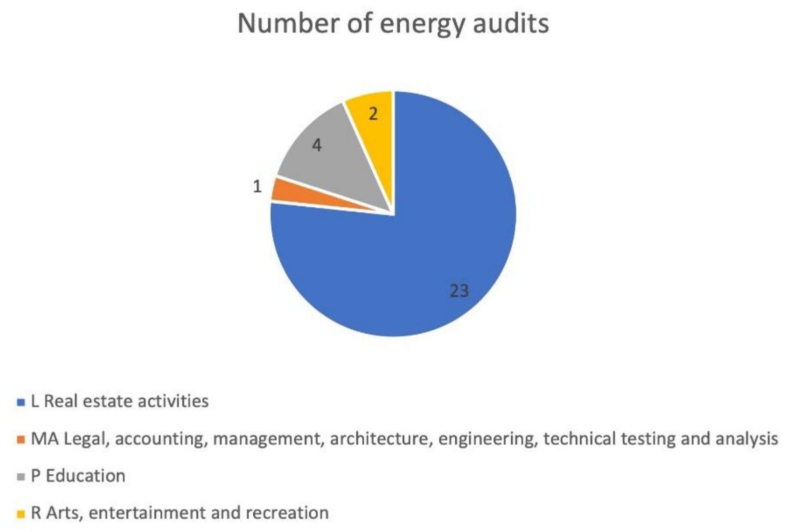

Figure 6, distribution of pilot energy audits over NACE divisions.

Energy use in the submitted energy audits

In total for the supplied energy, 9 GWh/year were mapped for 31 objects with additional 335 GWh/year for two extra-large energy using facilities in Russia, which in terms of CO_{2eq}- emission is equivalent to 65 000-tonnes (scope 2 accordingly to the Greenhous Gas Protocol).

The supplied energy is represented by mostly electricity (11%) and district heating (88%) with a little percentage of natural gas and the position Other for Sweden, Estonia, Latvia, and Poland. In Russia, the supplied energy is dominated by electricity (9%), district heating (38%), natural gas (26%), and LPG (26%) with a little percentage of diesel, gasoline, and coal.

In the Figure 6 and 7 below, the total energy end-use for member countries is presented. Energy end-use for Russia is presented on a separate figure due to the large difference in scale.

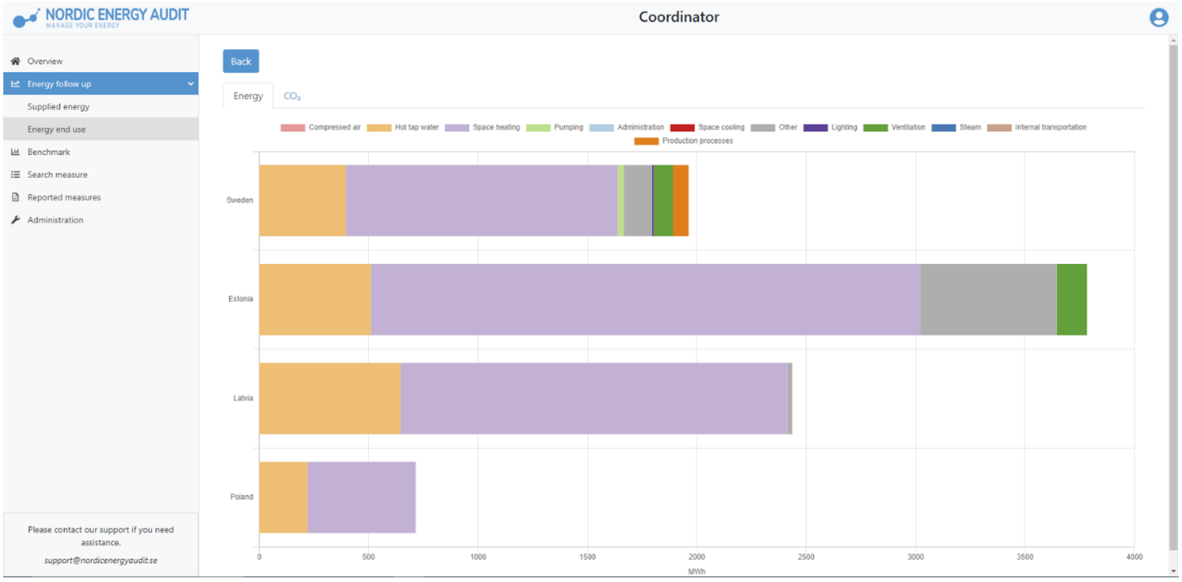

Figure 7, total energy end-use for Sweden, Estonia, Latvia & Poland. NEAD® screenshot.

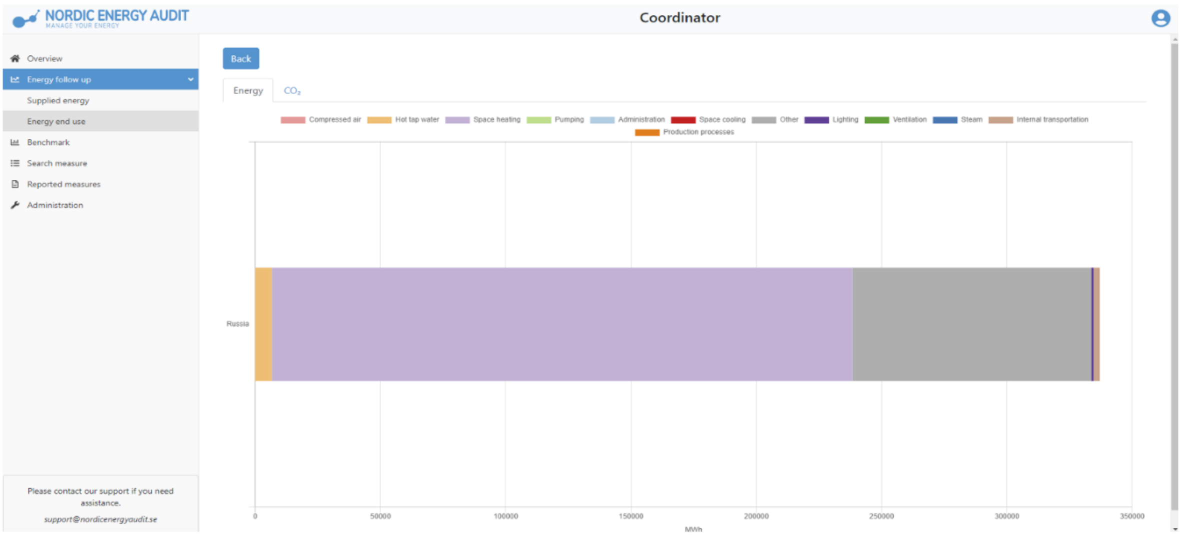

Figure 8, total energy end-use for 5 objects in Russia. NEAD® screenshot.

As illustrated, the energy end-use is dominated by Space heating (68%), followed by Hot tap water (20%) and Ventilation (3%) for Sweden, Estonia, Latvia and Poland. The position Other is accounted for 9%. In Russia the energy end-use is prevailing for Space heating (69%). Hot tap water and Internal transport are accounted for 2% and 1% correspondingly, and the position Other post represents 29%.

Energy data quality control

Once the energy data is inserted in the NEAD®-platform, it can be visualised in different forms. This helps to analyse the data and perform its quality control. The quality control that is being made possible with the methodology are the following.

- Number of reported information posts
- Accuracy of energy balance
- Benchmarking
- Reported measures – amount and accuracy

Below follows a description on the conducted quality control of the pilot audits.

Quality control - Number of reported information posts

Firstly, the number of reported information posts can be controlled (see Figure 8). Based on the number of reported information post, an indication of an energy audit quality can be obtained. Lack of some important posts makes it impossible to perform an extended analysis of a building energy performance. For example, if building area is missing benchmarking with other objects in a particular sector cannot be done. If all requested data is available and accounted for, a good indication of a object's energy performance can be created.

Post	Datatype
Site name	Text
VAT - Number	Combined letter (2 letters) and number code (7-12 digits)
NACE - code	Combined letter (1 letter) and number code (4 digits)
County	Text
Municipality	Text
Area	Number
Heated area	Number
Construction year	Number
Description if building has been renovated or not	Text
Hours of production	Number
Produced units	Number
Yearly revenue	Number
Number of employees	Number
Subscribed Power	Number
Fresh water usage	Number
Supplied energy	See page "Supplied energy"
Energy end use	See page "Energy end-use"
Weather normalisation method	Text/equation
Category	Mandatory Selection
Name of measure	Text
Expected yearly savings	Number accordingly to the page "energy end use"
Investment cost	Number
Payback time	Number
Life cycle cost (LCC)	Number
Net present value (NPV)	Number
Proposal date	Date
Planned date for implementation	Date
Implementation date	Date
Extent of measure	Text
Existing system	Text
New system	Text
Climate adaptation	Yes/no alternative

Figure 9, information posts from the SPEEED methodology.

Quality control - Energy balance

Another example of data quality control is by establishing the energy balance, i.e., allocating supplied energy and energy end-use and mapping it with each other. The amount of energy provided to a system should correspond to the amount of energy used. If these are not matched, a conclusion can be made that the entry data was incorrect, which is represented by the highlighted datapoint in column "Mapped energy" in Figure 10.

Your network

Company	NACE	Country	Region	Municipality	Supplied energy	Energy end use	Mapped energy
	6820				2019	2019	2019 100.00 %
	6820				2020	2019	2019 100.00 %
	6820				2016	2016	2016 139.32 %
	8531				2019	2019	2019 100.00 %

Figure 10, mapping supplied energy and energy end use. Screenshot from NEAD®.

Visualisation in the form of a Sankey diagram can facilitate determining the quality of an energy audit and the energy balance. A large discrepancy on how to define energy usage has been identified in the project. One illustration of an energy balance is presented in Figure 11. It is obvious from the Sankey that not much information regarding the object's energy performance can be obtained since it only accounts for supplied district heating and lacks other supplied energy sources and as well energy end-use.

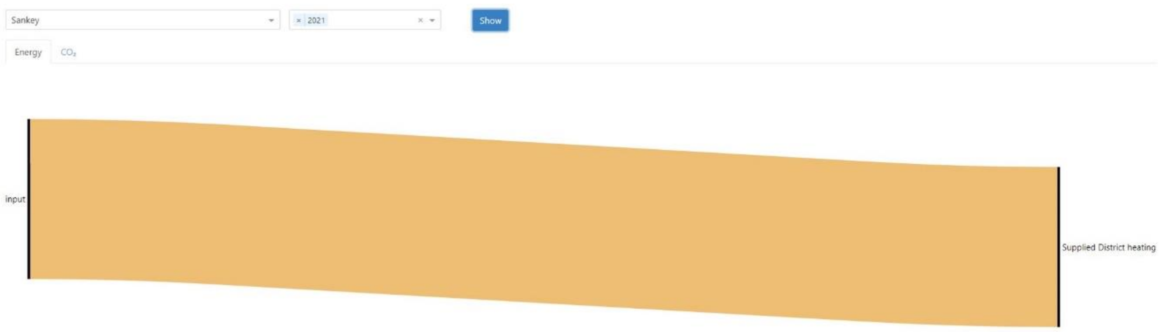

Figure 11, an example of an energy balance, unrepresentative. NEAD® screenshot

An example of an energy audit which produced a bit more representative energy balance is shown in Figure 12. Two energy carriers supplied District heating and Electricity have been divided among the end-use categories Hot tap water, Space heating and "Other".

Figure 12, an example of an energy balance, medium quality. NEAD® screenshot.

However, the ambition is to obtain an energy audit providing a highly detailed energy balance such as in Figure 13. It shows that instead of combining energy use into the "Other" post, an expansive categorisation was made, including Space heating, Lighting, Production processes, Space cooling, and Ventilation.

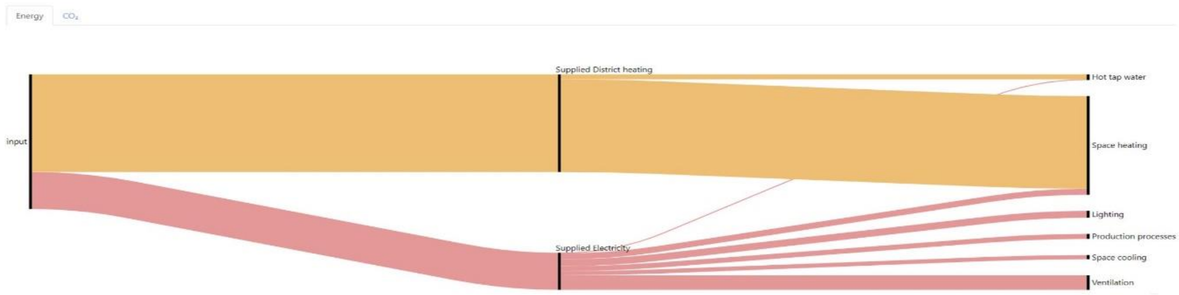

Figure 13, an example of an energy balance, high quality. NEAD® screenshot.

Quality control - Benchmarking

The third way of energy data control is by benchmarking. Since the NEAD® software contains data from approximately 800 energy audits from many different sectors, a baseline (or reference points) is available as comparison. This baseline or reference points is represented in the figures 14-16 by the blue dots and the CAMS audits are represented by the green dots. Please observe that not all CAMS pilot audits held the required quality to be benchmarked, which is why the number of green dots differ in the figures 14-16.

The benchmarking conducted has shown that all objects have an acceptable overall energy performance, see Figure 14, where no significant abnormalities was identified. In overall, the object's total use of energy per m^2 is 10% over mean or lower than the baseline.

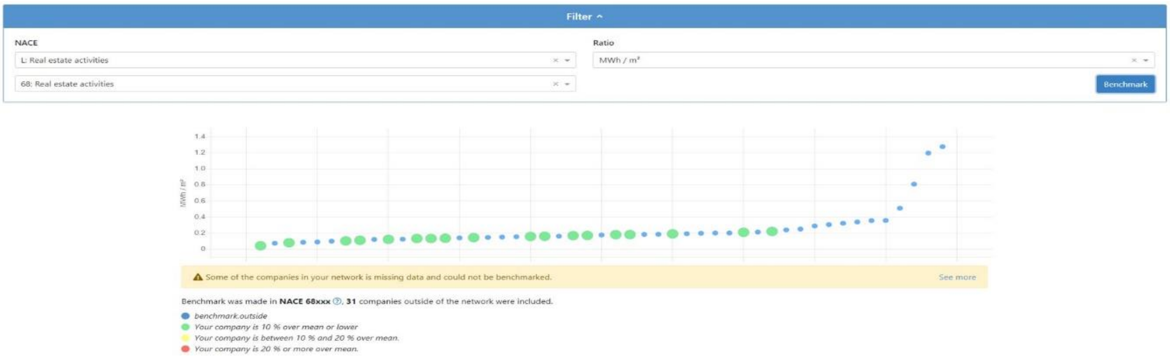

Figure 14, quality control & analysis through benchmarking: Total MWh/m². The green dots represent the CAMS audits and the blue NEAD®'s existing data. NEAD® screenshot.

However, some interesting results can be shown when categorizing data more specific, rather than on a general level. It can be seen in Figure 15, that in several facilities the energy performance for the end-use category space heating exceeds the mean values for the sector by 10-20%.

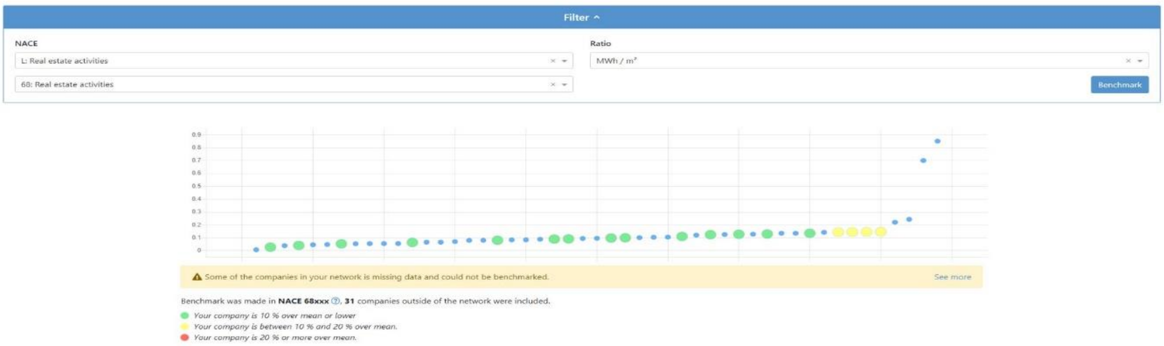

Figure 15, quality control & analysis through benchmarking: MWh Space heating/m². The green dots represent the CAMS audits and the blue NEAD®'s existing data. NEAD® screenshot.

Meanwhile as some CAMS objects has a lesser performance on space heating, the performance of luminaires is relatively good (probably since they all are newly built apartments with energy efficient equipment), see Figure 16.

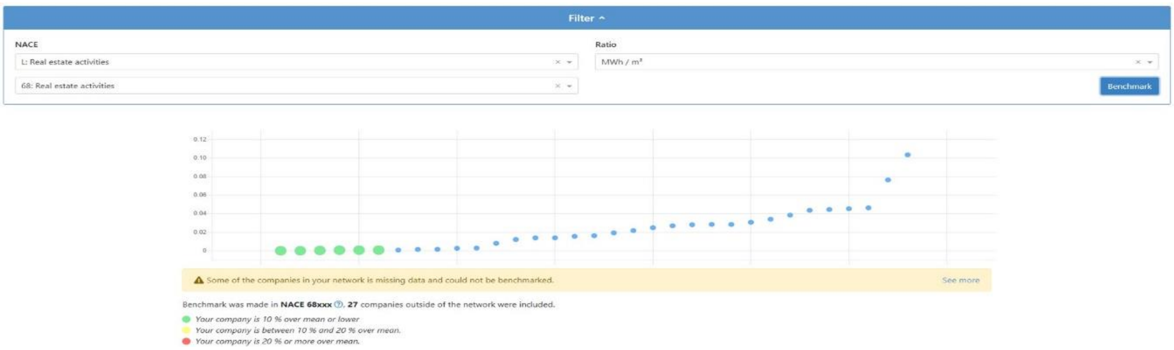

Figure 16, quality control & analysis through benchmarking: MWh Lighting/m². The green dots represent the CAMS audits and the blue NEAD®'s existing data. NEAD® screenshot.

Thus, benchmarking may provide an overview when aggregating data, but as well give an indication on which areas to prioritize in specific buildings or objects – and in a broader aspect contribute to identifying specifical improvement areas for specific economic sectors.

To establish continuously benchmarking possibilities and to ensure relevant comparisons, a more detailed categorisation of objects is needed. For example, when benchmarking within the NACE categorisation L – Real estate activities, a more detailed categorisation of building types is needed. One example of how this can be made is the Tabula project[3].

Quality control - Reported measures

Finally, an important quality indication of an energy audit is the suggested energy efficiency measures. The quality of energy efficiency measures suggested may vary and in Figure 17, a measure with insufficient description was suggested.

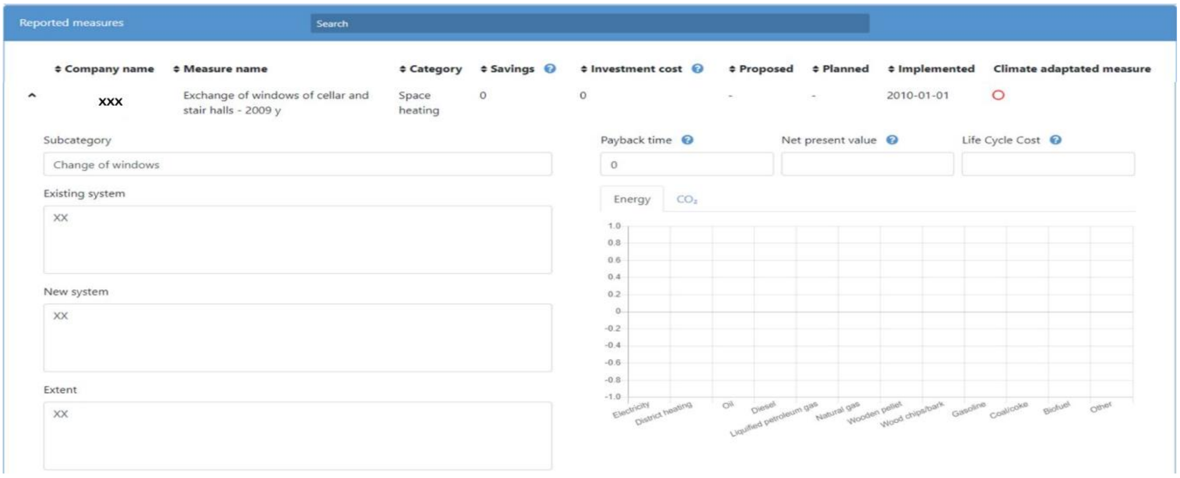

Figure 17, an example of a reported energy efficiency measure, lower quality. NEAD® screenshot.

A more detailed explanation of an energy efficiency measure is shown in Figure 18. Here, one can see that the description of an existing and the new suggested system was given. The measure extent and investment costs also were provided.

[3] https://episcope.eu/welcome/

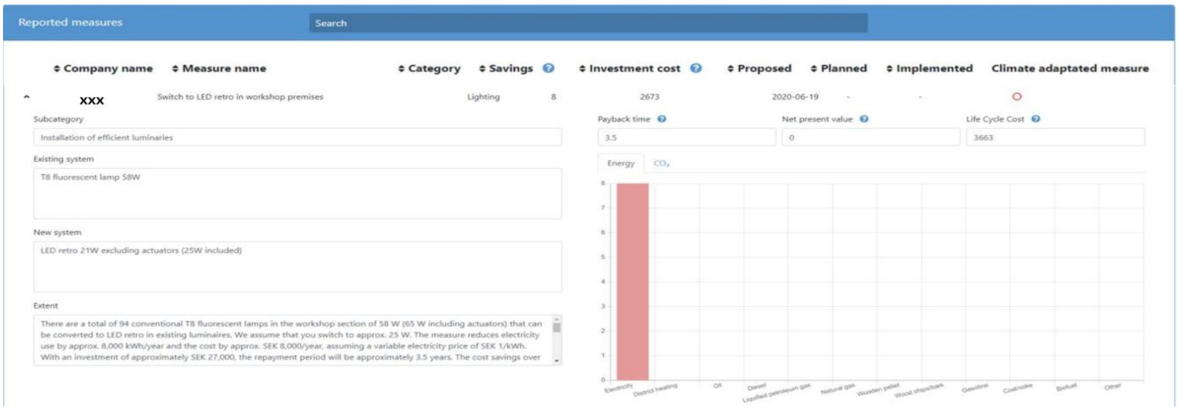

Figure 18, an example of a reported energy efficiency measure, high quality. NEAD® screenshot.

Since an energy audit aims on provide measures to decrease the energy usage, the measures are vital. More focus on increasing the quality of suggested measures from both audits and BEPC's are needed.

Energy saving potential in the submitted energy audits.

In total, 67 energy efficiency measures are registered in the project. However, only 12 of 33 energy audits have reported energy efficiency measures. None of them is related to climate adaptation.

The total energy saving potential for the reported measures is 2,8 GWh which corresponds to 30% of the total energy end-use for those audits containing measures. The total energy savings are equivalent to approximately 500-ton CO_2.

The categories of suggested measures are:

- Space heating – 64 %
- Ventilation – 16 %
- Energy supply – 8 %
- Lighting – 8 %
- Hot tap water – 3%
- Space cooling – 1%.

Using such method as conservation supply curves (CSC) is an efficient way of displaying the cumulative impact of suggested energy efficiency measures. In Figure 19, a CSC was constructed in terms of specific costs of energy saved by means of suggested measures. Please advise that only 15 of the 67 reported measures acquired the quality to perform the analysis.

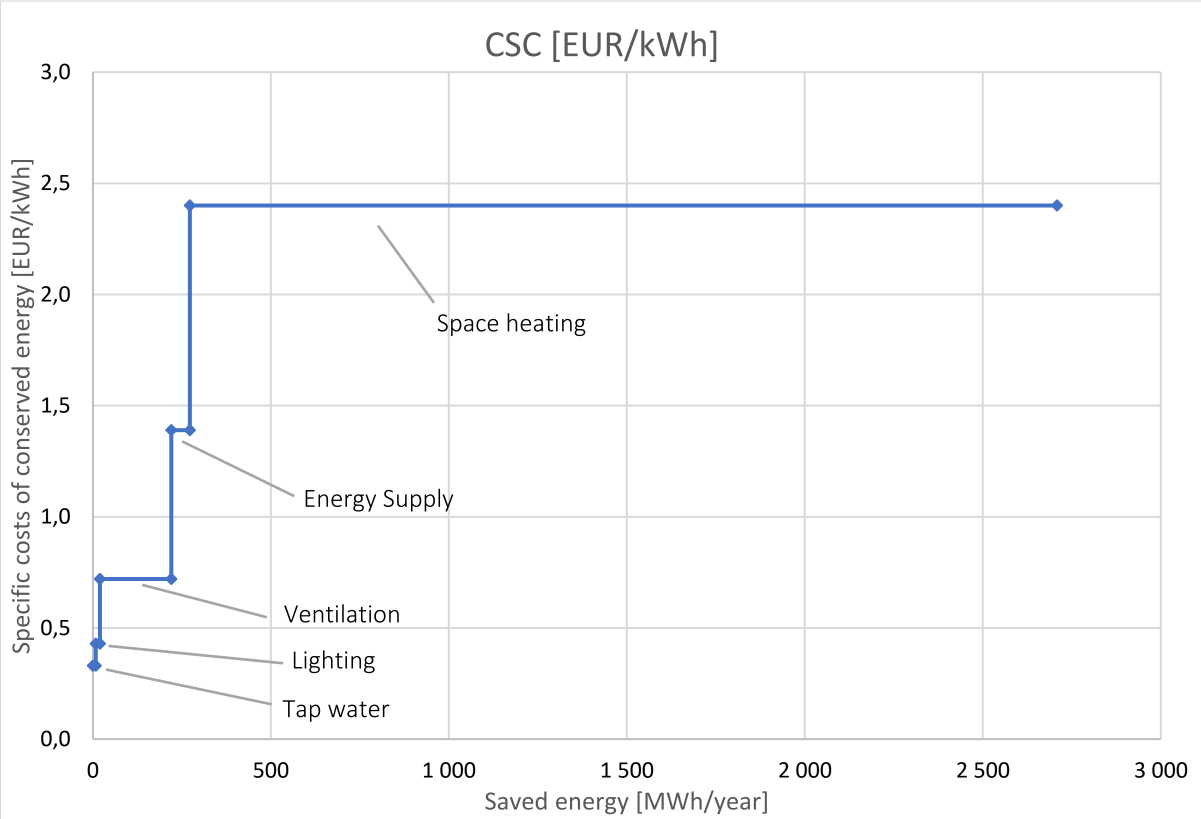

Figure 19, cost efficiency of energy efficiency measures in terms of energy savings for reported measures.

In this case, measures suggested in the group Hot tap water and Ventilation have the lowest cost per kWh saved, while Space heating have the highest. Despite having the lowest cost efficiency, space heating was the most frequently reported category.

The same can be presented in terms of amount CO_2 saved, see Figure 20, where a similar tendency holds: Hot tap water and Ventilation measures have the lowest cost per saved kg CO_2 while Space heating have the highest.

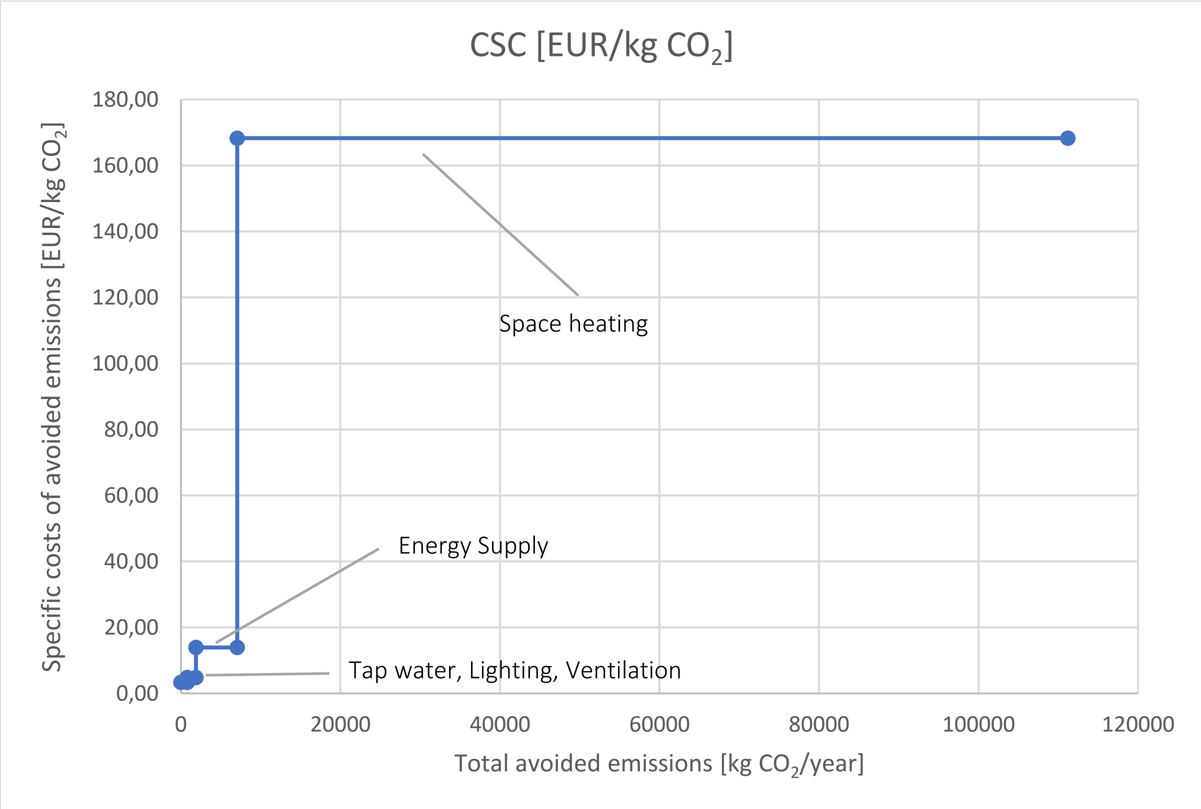

Figure 20, cost efficiency of energy efficiency measures in terms of avoided CO_2 emissions.

In Figure 21, it is shown how the energy end-use is distributed among different processes within the analysed objects. Space heating requires the highest energy use, followed by Hot tap water and the category Other with unspecified energy end-use.

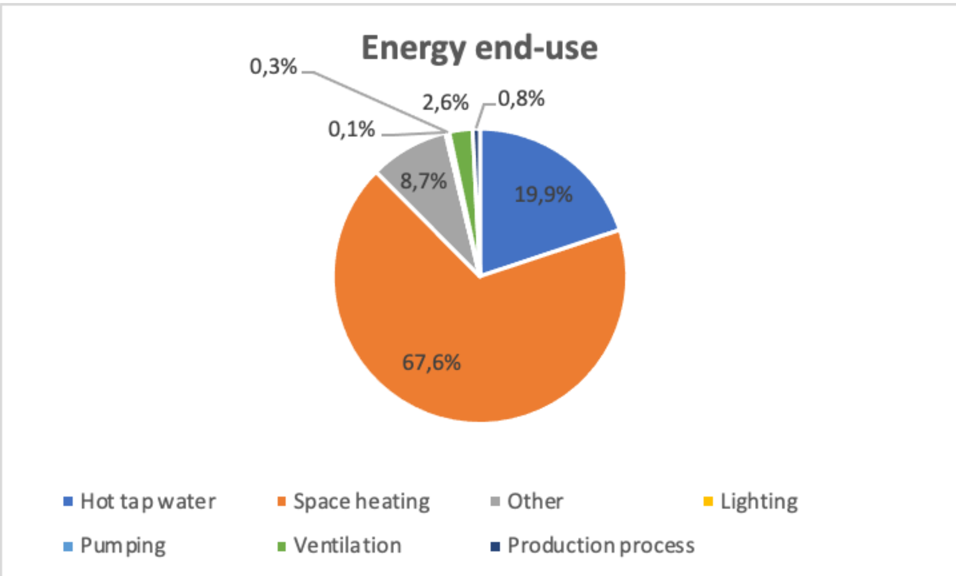

Figure 21, shares of energy end-use by different processes.

An interesting finding is that almost all measures were suggested for Space heating, followed by much fewer measures' suggestions for Ventilation. The share of rest of measures is insignificant and cannot even be seen on the diagram in Figure 22.

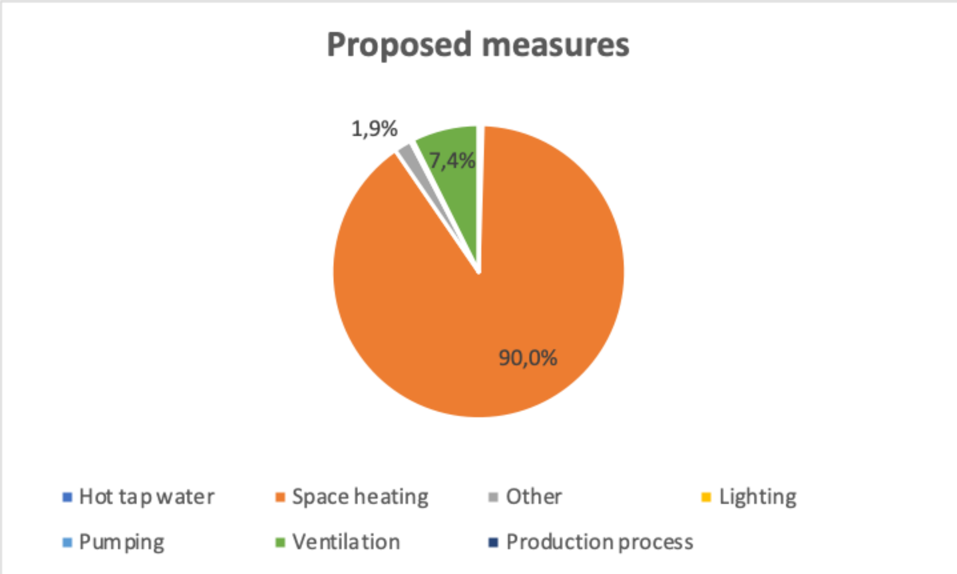

Figure 22, shares of energy end-use by proposed measures.

Survey results and National energy audit days

As one part of the project plan, National Energy audit days were arranged, where different national stakeholders were invited to participate. The National energy audit days were conducted in an online format due to the COVID-19 situation and two presentations, "Introduction to the SPEEED methodology" and "State of the art in energy auditing", based on the project was held. The discussions afterwards and feedback were in general good and engaging.

Afterwards, the survey on energy audit methodology and digital tools was performed. In total 28 respondents from 5 countries participated and the respondents almost exclusively were energy engineers or equivalent. Even though the sample size is small, three major areas of challenges could be observed:

- To generate data to a satisfying extent
- To ensure a high quality
- A standard approach/methodology/reporting format etc. for an audit.

The issues regarding data generation are difficult to address with the applied methodology, since it is the core of an audit. Currently the data in an audit is either estimated, calculated and/or measured. This relates to costs and quality, since estimations are least cost intensive, followed by calculations and measurements (most expensive).

Another interesting aspect is the conclusion that no standard approach for audits exists, despite defined standards (ISO 50002 and the European standard EN 16247). Furthermore, national regulatory bodies define some basic demands, but these are evidently not sufficient to ensure a high quality of audits.

Furthermore, most of the respondents are positive to using digital tools to facilitate their work, which gives good indications for that digitalisation of the area of energy efficiency is both wanted and needed.

Stakeholders' evaluation of energy audit data systemization method in Baltic Sea Region

The specific platform (NEAD®) and the systemization methodology (SPEEED) has been evaluated by project partners and relevant national stakeholders. The full extensive evaluation report, "Summary of policy recommendations on introduction of energy audit data systematization method (NEAD platform) in Baltic Sea Region", can be accessed from the CAMS website[4]. This chapter summarizes the major learnings the report.

When evaluating digital tools and databases, it was found that Latvia and Sweden currently collect energy audit da5a, but without any coherent and consistent usage of the information. Furthermore, no open access is offered for interested stakeholders. No systemization on collecting energy audit data is currently ongoing in the other partner countries Estonia, Poland and Russia.

Each partner country has accounted for their general standpoint regarding introducing a systematic way to collect energy audit data. All partners agree on that a systematic way of data collecting for further energy data analysis is needed and that it is necessary to develop a standardized data collection methodology. The majority also agree that benchmarking possibilities on BSR level would be an additional motivation to increase the quality of energy audits. Also, it is partners opinion that the use of a common platform would bring large benefits if it were based on a few common principles, including standardized categories of data.

Partners have also evaluated the specific methodology (SPEEED) and platform (NEAD®) which was used in the project. It is important that these are concrete examples of "how" to systematic collect energy audit data. For the time being, it is more important to reach consensus on whether data systemization is the way forward for the BSR partners. Therefore, the evaluation of NEAD® and SPEEED is not further accounted for in this report. For this matter, the reader is advised to the evaluation report "Summary of policy recommendations on introduction of energy audit data systematization method (NEAD platform) in Baltic Sea Region",

[4] For documentation, see https://trea.ee/cams.

[5] Please advise that this section refers to energy audit data, and not BEPC data, which in all partner countries are collected to some extent.

Partner feedback, challenges, opportunities, and future work

As a concluding part of the Results chapter, the project partners' feedback, and learnings from applying the methodology are presented, highlighting the challenges and opportunities with its use.

A general learning is that there is not enough knowledge regarding the overall energy performance of an object. Applying the energy audit data within NEAD® showed that the allocation of energy end-use is difficult. Nevertheless, allocation of energy end-use is an important parameter of a high-quality energy balance. Also, there is not much focus on providing attractive and informative proposals for energy efficiency measures. The quality of energy efficiency measures suggested differing significantly and are very often difficult to motivate and perform an appealing investment appraisal on.

The main concerns from the projects partners when using the methodology are the following:

- Motivation for stakeholders to use the platform. In other words, it is necessary to clearly present the benefits of energy data harmonising and categorisation for all stakeholders.
- The end-use categories/golden standard used in the project are more applicable for industrial processes rather than building sector. Therefore, further work on how to improve reporting format is needed.
- A standard approach for CO_2-equvivalents is required since there are three different ways of defining it (Scope 1, Scope 2, and Scope 3 according to the GHG Protocol corporate standard). Since all energy usage always can be associated with environmental impact, it's important to have accurate estimation on e.g. corresponding CO_2- equivalents for supplied energy carriers. These equivalents also are different for different regions/countries, which also needs to be taken into consideration.

The partner feedback regarding the used platform in the project revealed some major developments points of it:

- Adjustments to information posts for buildings
- Further clustering/categorization of buildings
- "Golden standard" applicable, adjustments needed for each cluster
- Further development of end-use categories for buildings, and their deeper classification
- Possibility to describe current status of an object
- Possibility to declare degree days, in order to weather normalize figures.
- Calculation support (investments appraisals, normalization, etc.)
- Handling of documentation.

Furthermore, gap analyses have been made on improvement points for the NEAD® platform to be compliant with national regulations regarding BEPC and auditing methodologies. The results are that the current platform needs to be adjusted in different extent, but for some countries further integration will be investigated.

Conclusions

In general, the idea for doing an energy audit is basically the same for all type of buildings and businesses in all partner countries; to map energy supply, distribute the energy to end-user as well as map, calculate and present possible measures. However, the quality of audits differs both within a nation and as well between different nations. Even though there are guidelines setting the standard for what information should be included in an energy audit in all partner countries, basic data is often missing and data for energy use and measures do not match.

Energy audits have some basic control, but without competence of an expert it is hard for an authority to identify failures. At the same time, audits for obtaining BEPC hold a significant lower quality compared to real energy audits in all partner countries and quality control of BEPC and proposed measures are not being done. Data from BEPC is being collected in some way or another in all partner countries but it is not possible to aggregate data or to benchmark. Only single BEPC can be extracted from the database at a time.

Several factors contribute to low quality energy audits. One reason for low quality audits is, of course, the cost factor. Experienced auditors time is costlier than unexperienced auditors, and when cost is decisive - auditors cannot allocate and spend sufficient time to do audit properly, which results in a lesser quality of the audit. With low quality audits, comes low possibilities to increase the energy efficiency of the audited object. In the long run, this brings unwanted market mechanisms in terms of low incentives for high quality audits and BEPC, and thereby lowering the pace for increased energy efficiency in general.

The competence of auditors is generally not high enough and for most partner countries there is no system for quality control of auditors. Very often an understanding and knowledge in system perspective are missing, where having experience in one technical field is common but many auditors have less competence in other areas. Since it can be difficult to gain experience for all types of buildings/business sectors, auditors might need to specialize in some few.

The technical competence of the auditors is however relatively high. More lacking is the awareness on how digitalization, different types of economical appraisals and the connection to sustainability can contribute to the core of the auditors' work – to increase energy efficiency. These are vital areas that in the future and needs to be more highlighted and educated within, not only among auditors, but for all different stakeholders.

Overall, even if countries have responsible authorities for implemented the EU directive and have developed national policies for energy efficiency, a clear responsibility for actual implementing energy audit programs in large scale and measures is lacking. For this a more centralized approach is needed. There is a lack of policy and support schemes that actual meet the need of conducting energy audits in a larger scale than currently. Partners in the project welcome stronger regulation and tougher implementation of the directives as well as more incentives for voluntary energy audits.

In general, not much focus is on energy efficiency measures nor key figures to create benchmarking opportunities (primarily m^2 and m^2 heated area for residential buildings). The energy balances mainly focus on heating demands, where district heating, space heating and hot tap water are most accounted for. Allocation of electricity is often unclear (probably due to the lack of reporting possibilities, e.g. no suitable allocation for elevators in residential buildings). In one Russian case, many end-use categories and supplied energy types are accounted for, which may indicate that a large potential exists for increased quality on energy data. For the Swedish cases, most measures were described thoroughly, while in Estonia and Latvia, each measure is described in only a few words. In some Estonian cases, neither savings nor investments costs were reported. In Russia and Poland, there were no measures reported at all.

Thus, a common conclusion is that there is a big difference in energy audit qualities among the countries in the Baltic Sea Region caused by differences in national legal circumstances and procurement approaches. Distributing energy use into specific standardized categories brings added value to energy auditing. It enables possibilities for benchmarking and generation of valuable data that can be scaled up to new knowledge and for energy efficiency support schemes. Therefore, there is a great untapped potential in collecting data from energy audits in a uniform and standardized way.

The handling of reported audits afterwards is non-existent for now, which is a problem that should be handled in a centralized way by authorities rather than a single energy auditor. Audit results should be accessible to different users and bolster energy efficiency assessment and improvement. With a central collection node that clearly defines what has to be analysed and reported, a substantial quality control, benchmarking, and knowledge exchange is possible. For that, a larger number of data points need to be collected.

One important area to highlight is the incentives for different financial institutes to issue green loans, which most often is associated to high risks. If a measure database with the suggested methodology is established, real proof for that energy efficiency measures are profitable over time can be presented and many benefits can be achieved:

- Financial institutions: Decreased risks, more loans and thereby more revenue, and as well green profile since they support decarbonization and agenda 2030.
- Private sector: More financial support for investments, decreased energy usage and increased decarbonization pace.
- Public sector: Increased possibilities to form accurate policies.

All this brings to an idea of necessity of an integrated national and/or international energy audit database for energy efficiency end-use data and improvement opportunities. A platform/database where auditors can search for previous energy audits would enable comparisons and generation of new knowledge for different public and private actors:

- A standardized energy audit data collection can contribute to obtaining a comprehensive picture of buildings' energy performance.
- A good benchmarking process allows companies and building owners to compare themselves to others and improve their conditions.
- Collecting and providing data from previous energy audits can inspire auditors and support them in finding more possible energy efficiency measures.
- A centralized integrated database can contribute to forming relevant future policies and guidelines and can be used to evaluate current/historical ones.

- Scaling up energy audits using innovative digital database may highly increase the cost-effectiveness of energy efficiency policies.

Most often, existing databases do not enable comparison between countries, sectors, companies, and processes. There are different taxonomies, units, and formatting used in different countries and organisations which makes it hard to compare. The database analysed in this project combines and integrates energy data from different international data sources which makes it quite unique. It helps to perform a complete mapping and visualisation with a possibility to downplay a multilingual issue. Also, using the database gives more inspiration on neglected areas of improvements which is crucial if such experience is lacking.

Some further possible analysis with the database approach is:

- Total saving potential
- NACE saving potential
- Geographical saving potential
- Implementation pace
- Decarbonzation pace.

For now, the allocation of energy end-use is not often done in a proper way and the NEAD® database represents a good opportunity on overcoming these challenges. The majority of project partners were interested in using the platform in their occupation, but clear policy recommendations and further work are required. The identification of improvement opportunities for the database development would be difficult without the partners' input.

The main improvement areas in the SPEEED methodology are adjustments to information posts for buildings, an improvement of clustering/categorization of buildings, an adjustment of "Golden standard" for each cluster, and a deeper development of end-use categories for buildings. For that it is required to further implement the methodology at stakeholders as well as to large-scale test it at one stakeholder. To motivate stakeholders to use the platform, it is necessary to clearly present the benefits of energy data harmonising and categorisation. Also, it is important to further investigate the possibility of the platform's integration within the context of different international regulations regarding BEPC and auditing methodologies.

To conclude, most initial goals of the project were clearly achieved: a concrete approach/methodology on how to work with digital tools, energy efficiency & decarbonization was applied and tested. A collection, harmonisation, and visualisation of energy & environmental data were performed. A concrete know-how was applied to quality control energy data. A proof of concept on how to generate new knowledge for design of policy and energy efficiency programs and decision making was made.

Conclusions & further work:

The major conclusions for this project are as follows:

- This project is a Proof of Concept for how to improve audit methodology and how to work with digital tools, energy efficiency and decarbonization. It has been shown that it is possible to harmonize, collect, quality control and visualize data from audits. Based on this data, new key knowledge for policy and decision making has been created.
- The utilization of digitalisation in combination with a well-designed methodology within the area of energy efficiency, energy audits and BEPC would enable:
    - Highly improved monitoring and control regarding e.g. cost effectiveness of energy efficiency measures/policies. A digital approach enables improved monitoring and evaluation of e.g. energy audit programs in large scale. For this, a more standardized and centralized approach could be of great use.
    - Continuously benchmarking of energy use, which brings insights for all stakeholders.
    - Establishment of a database containing energy efficiency measures that can increase the incentives for implementing efficiency measures[6]. E.g., real evidence may lower risks regarding grants for green loans.
- No central quality control of energy audits and BEPC decreases the pace for increasing energy efficiency since no incentives for high quality audits and BEPC exists. It is also difficult to verify whether audits and BEPC has been performed by everyone that are required to have them.
- There exists a great potential in centralized, uniform, and standardized collection of data from audits and BEPC. For the time being, the collection is almost non-existing and where it does exist, no utilization of the data is occurring.
- Project partners welcome stronger regulation and tougher implementation of Directives and more incentives for voluntary energy audits.
- Clear guidelines on how to connect energy usage to $CO_{2,\,eq}$ is requested.

To realize the identified improvement opportunities as well as to accomplish the areas that were less covered in the project (such as increasing pace of energy audits and reducing energy audit costs), the following projects are suggested:

- A project focusing on implementing energy efficiency measure database(s).
- A common project on improving and harmonizing energy audit methodology and data handling.

In all, both projects would contribute to accelerate the pace for increasing energy efficiency in the European Union and towards the goals of Agenda 2030.

[6]This statement if supported in the 2015 EEFIG report "Energy Efficiency – the first fuel for the EU Economy", where energy- related databases have one important role in order to remove barriers for energy efficiency.

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Annex 1: List of stakeholders

The following stakeholders has been identified as relevant for the SPEEED-methodology.

Estonia:

- Tartu Regional Energy Agency
- The Ministry of Economy and Communication
- The State Real Estate Ltd
- Estonian Union of Cooperative Housing
- Estonian Society of Heating and Ventilation Engineers, certifying body of auditors
- Talltech
- The Tartu city government, building office
- The Tallinn city government, strategy office
- The Stockholm Environment Institute Tallinn office
- Multiple energy management, engineering and consulting companies
- Energy auditors in their SME

Latvia:

- Ministry of Economics
- The State Construction Control Bureau of Latvia (administrates Building Information System)
- Association of Heat, Gas and Water Technology Engineers of Latvia
- Ltd EKODOMA – engineering consulting company, industry leading energy auditors, researchers.
- Baltic Environmental Forum Latvia
- Riga Energy Agency
- Kurzeme Regional Energy Agency
- Campaign/stakeholder platform "Let"s live warmer!"

Sweden:

- County Administrative Board of Dalarna
- Boverket - National board of housing, building and planning
- Energimyndigheten – Swedish energy agency
- Naturvårdsverket – Swedish environmental protection agency
- Länsstyrelser – 21 County Administrative Boards of Sweden
- Energikontoret Dalarna - Regional energy agency
- Energikartläggare - Energy auditors

Poland:

- Foundation of Energy Saving in Gdansk
- Ministry of Development, Labor and Technology, Department of Low-Emissions Economy (National gov. body responsible for the longterm Renovation Strategy of Buildings)
- Marshal Office of Pomeranian Region, Energy Planning Department
- Regional Fund for the Protection of Environment and Water Management – Energy Advisors team

- Association of Energy Auditors (ZAE)
- Association of Energy Conservation Agencies (SAPE)
- Polish Ecological Club (NGO within the Climate Coalition in cooperation with 25 other NGO's active at the national and transnational level)
- the two municipalities of Sopot and Władysławowo
- the Housing cooperative MSM Szkuner I
- the Real Estate managing company in Gdansk

Russian Federation:

- Peter the Great St.Petersburg Polytechnic University (SPbPU)
- Ministry of Energy
- Committee on Energy and Engineering Support of St. Petersburg
- Committee for the Fuel and Energy Complex of the Leningrad Region
- State budgetary institution "Energy Saving Center" of Saint-Petersburg
- State Treasury Institution of the Leningrad Region "Center for Energy Saving and Energy Efficiency of the Leningrad Region"
- Self-regulatory energy audit organizations
- Energy auditors

Annex 2: Golden Standard for improved energy data handling

General information regarding the object of auditing:

- Object name
- VAT-number
- NACE-code
- Country
- County
- Municipality
- Total object area (m^2)
- Heated object area (m^2)
- Hours of production (h/year)
- Produced units (different alternatives)
- Yearly revenue (EUR)
- Number of employees
- Number of degree hours (amount/year)

Energy related data:

- Supplied energy
    - Maximum power that is declared in the electricity contract (kW)
    - Fresh water usage (m3/year)
    - Amount of each energy carrier that are supplied to the object (MWh/year)
        - Electricity
        - District heating
        - Oil
        - Diesel
        - Liquified petroleum gas
        - Natural gas
        - Wood pellets
        - Wood chips/ bark
        - Gasoline
        - Coal/coke
        - Biofuels
        - Other
    - Emission factors for each energy carrier (kg CO2eq/MWh)
- Energy end use
    - Amount of each energy carrier that is supplied to each category of end use processes (MWh/year):
        - Production processes
        - Compressed air
        - Lighting

- Space heating
- Space cooling
- Ventilation
- Hot tap water
- Steam
- Pumping
- Internal transportation
- Administration
- Other

Energy efficiency measures data

- Category (as is predefined)
- Subcategory (as is predefined)
- Name
- Expected yearly energy savings (MWh/year)
- Investment cost (EUR)
- Payback time (years)
- Life cycle cost and Net Present Value (EUR)
- Date when the measure was proposed
- Planned date of implementation
- Implementation date
- Extent of measure
- Existing system
- New system
- If the measure in any way has a connection to climate adaptation

Annex 3: Survey Questions

This survey are to the attendees to the webinar "National energy audit day" and are estimated to take 15 minutes to conduct. First, we need some general information.

*Mandatory

In which role did you attend? *
Energy Auditor
Energy expert
Official
Other:

Which category are you mainly working against?
Real estates
Buildings in general
Industry
Other:

Are you in some way involved in the CAMS project? *
Yes
No

If yes, please specify how

*Mandatory

Challenges with energy auditing

This part focus on the work of energy auditors and the energy audit process

Please specify some major challenges with an energy audit that you experience *
The energy auditors may describe hands on difficulties, officials may e.g describe administrative challenges.
Your answer

For officials: can you briefly describe how an energy audit report is handled internally?
E.g regulatory/reporting demands, how reports are collected, how the data are analyzed, results, etc.
Your answer

Where do major challenges appear in the audit process? *
Startup-meeting
Site-visit(s)
Analyze data & establish the energy balance
Writing the report
Hand over results
Other:

Please specify why

Your answer

Which parts of the audit process are most time consuming? *

Startup-meeting
Site-visit(s)
Analyze data & establish the energy balance
Specifying energy efficiency measures
Writing the report
Hand over results
Other:

Please specify why

Your answer

How often does the following posts occur in an energy audit report? *

For those who not are energy auditors to occupation, please input how often the posts appear in an energy audit report.

Never
Seldom
Common
Always
Don't know

Total object area
Total heated object area
Construction year
Renovated or not
Energy consumption/m2
Supplied primary energy (oil, electricity, gas etc.)
Emission factors for primary energy
If a value have been calculated or actually measured
Weather normalization
Total object area
Total heated object area
Construction year
Renovated or not
Energy consumption/m2
Supplied primary energy (oil, electricity, gas etc.)
Emission factors for primary energy
If a value have been calculated or actually measured
Weather normalization

Please specify if any reporting posts of relevance are missing *

Your answer

Which energy end-use posts are most common to report in an energy audit *

Never
Seldom
Common
Always
Don't know

Lighting
Space heating
Space cooling
Dehumidification/Humidification
Ventilation
Water usage/hot tap water
Steam
Pumping
Administration
Lighting
Space heating
Space cooling
Dehumidification/Humidification
Ventilation
Water usage/hot tap water
Steam
Pumping
Administration

Please specify if any vital reporting posts are missing *

Your answer

Which posts are accounted for when reporting energy efficiency measures? *

Never
Seldom
Common
Always
Don't know

Energy savings distributed over energy carriers
Investment cost
Payback-time
Life cycle cost (LCC)
Net present value (NPV)
Extent of measure (e.g. 1000 new led fittings
New system (description of the new system)
Existing system (which are to be replaced)

Climate adaptation or not
Energy savings distributed over energy carriers
Investment cost
Payback-time
Life cycle cost (LCC)
Net present value (NPV)
Extent of measure (e.g. 1000 new led fittings
New system (description of the new system)
Existing system (which are to be replaced)
Climate adaptation or not

Please specify if any vital reporting posts are missing *

Your answer

*Mandatory

Digital tools and energy efficiency

This chapter aims to investigate how digital tools can facilitate an increased energy efficiency

Could a digital tool help you in any way in any stages of the audit process? *

This question primarily aims to energy auditors

Startup-meeting
Site-visit(s)
Analyze data & establish the energy balance
Writing the report
Hand over results
Other:

If yes, please specify how

Your answer

Would a central database of energy efficiency measures be of any use for you in your occupation? *

Yes
No
Maybe

If yes (or maybe), please specify how

Your answer

Would a central database of energy end-use be of any use for you in your occupation? *

Yes
No
Maybe

If yes (or maybe), please specify how

Your answer

Would a reporting-portal where key information from an energy audit are inserted and stored be possible to use in your professional practice? *
Yes
No

If no, please specify why
Your answer

Would you be interested in using a digital platform in your professional practice? *
Yes
No
Maybe

Do you have anything else to add on the topic "digital tools"?
Your answer