

ENERGY AND ENVIRONMENTAL AUDIT FOR SUSTAINABLE BUILDINGS



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1 Introduction

Nowadays has an inquiry regarding to the energy consumption in existing buildings top priority in Slovakia too. The energy consumption of Buildings is a social phenomenon which should be analyzed and specified for each partial problem. This was the reason to create an application for a quick and easy handling based on European standard as CEN 832, etc

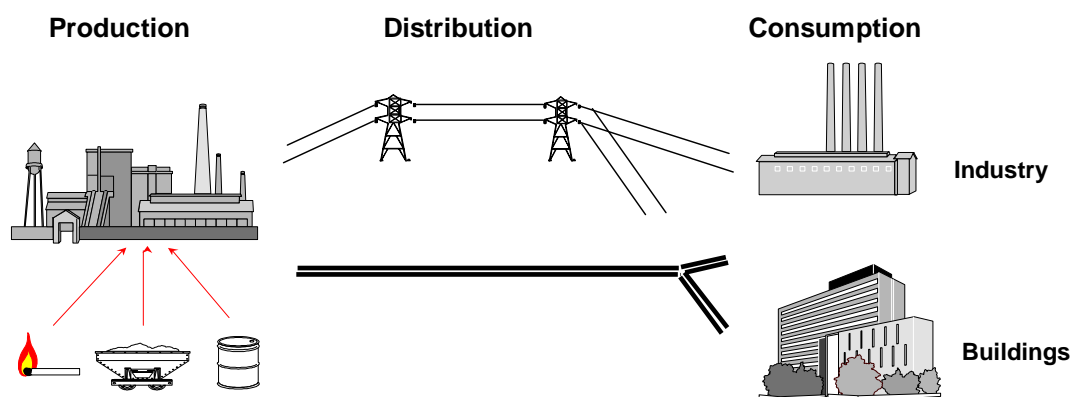


Fig. 1 Energy scheme of the country

A total energy efficient system is achieved by evaluating all elements, and making appropriate improvements where needed. This document deals with one part of the consumption element; **BUILDINGS** (office buildings, apartments, schools, hospitals, gymnasiums, etc.). This document describes the methodology for the total ENCON Process being used by ENSI[®]. The methodology is "universal" and can be applied to buildings world-wide.

2 The ENCON process

Every building is unique. Therefore each project must be treated separately to find individual energy conservation possibilities. The building owner might have various plans for renovation and different requirements for the profit of ENCON measures (maximum Payback time). It is necessary to approximate possibilities and economic consequences of the project prior to spending a long time on detailed investigations.

The total ENCON Process is divided into six main activities/steps as illustrated in the flow chart.

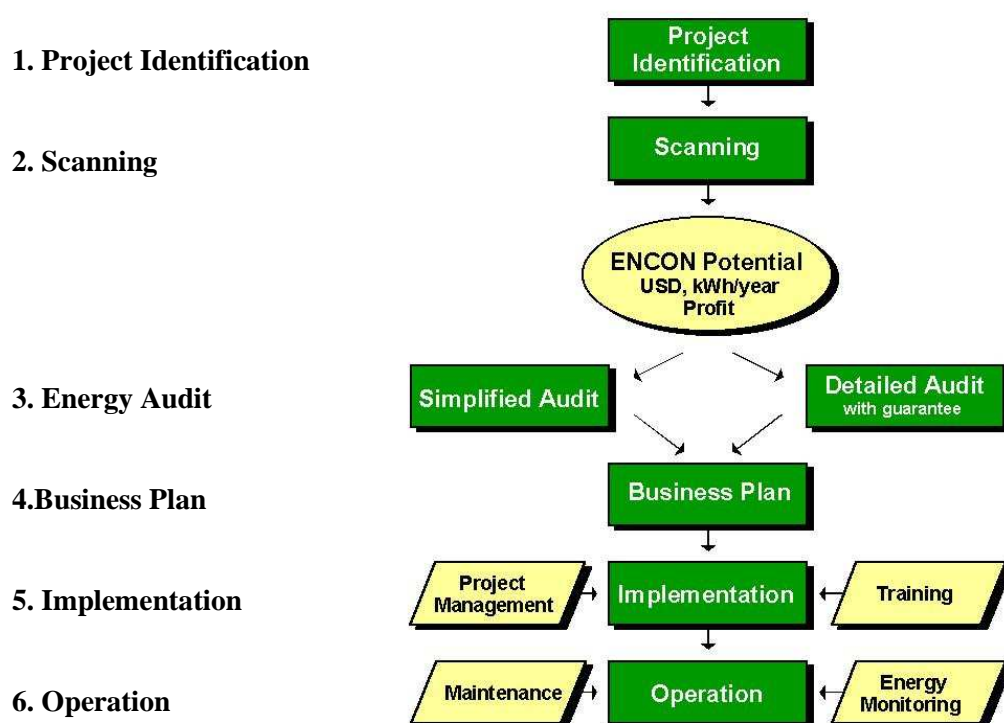


Fig. 2 Scheme of ENCON Proces

If the information gathered during the **Project Identification** phase reveals a beneficial ENCON project, a **Scanning** is carried out. The scanning process will assess whether profitable ENCON installations could be made.

The Scanning Report contains:

- Total energy saving potential
- Total investments required
- Total Payback time (profitability)

If the building owner finds the saving possibilities beneficial, the process will continue with an **Energy Audit**, which may be detailed or simplified. The level of accuracy is different for a simplified and detailed audit, and only a detailed audit could include an energy guarantee. If the building owner needs external financing for the project, or in case there is a proper clarification on the investment required, the process will continue with the development of a **Business Plan**. During the **Implementation** period, the personnel in charge of operation and maintenance are given thorough training on all systems and

equipment. This training ensures an energy efficient **Operation** of the building. After ENCON measures are implemented, the installed routines for operation and maintenance and energy monitoring will contribute to ensure the energy consumption remains permanently at a low level.

3 Project identification

The Project Identification phase includes:

- Dialogue with the building owner
- Collection of main building and technical information
- Collection of energy consumption statistics from previous years
- Evaluation of the owner's interest in accomplishing a total project implementation
- Evaluation of the owner's business possibilities

If the Project Identification indicates a positive development and the project seems to be beneficial for both the building owner and the ENCON company (consultants), then the process would continue with a Scanning.

4 Scanning

During the Scanning, the following procedure is used:

- Preparations
- Inspection for specification of the present situation
- Energy calculations
- Economical calculations of the ENCON measures
- Development of a Scanning Report
- Presentation and discussion with building owner to agree on the further development

The standard Scanning Report includes:

- Profit Evaluation: total savings, investments and payback
- List of suggested ENCON measures
- Proposals for renovation measures
- Evaluation of indoor environment and maintenance routines
- Present energy consumption and energy prices

The total profit evaluation for all recommended measures is given in a form as illustrated in **Tab. 1**.

Tab. 1 Scanning Report – Profit Evaluation

PROFIT EVALUATION					
Energy saving	327 000	kWh/year	Net saving	31 200	USD/year
Investment	105 000	USD	Payback	3,4	years

The results presented in the Scanning Report normally have an accuracy of $\pm 20\%$.

5 Energy audit

Depending on the building owner's needs and guarantee requirements, there are two alternatives for an Energy Audit:

- **Simplified:** The simplified Energy Audit is the least costly and normally has an accuracy of $\pm 10\text{-}15\%$
- **Detailed:** The detailed Energy Audit is more extensive, but it can include a guarantee for energy savings with an accuracy of $\pm 5\text{-}10\%$

Both types of Energy Audits lead to an Energy Audit Report including:

- The ENCON Potential (measures, investments, savings and profit)
- Specification of the existing situation
- Detailed description of each ENCON and renovation measure
- Environmental aspects
- Time schedule for implementation
- Financing
- Criteria for energy guarantee (only for detailed energy audit)
- Operation and maintenance
- Energy monitoring
- Training of operation and maintenance personnel

The main figures of an Energy Audit are presented as in **Tab. 2**.

Tab. 2 Energy Audit Report – ENCON Potential

ENCON Potential – Energy Audit					
Building: ENSI Head Office, Oslo**		Project no: 10130		Heated area: 2300 m ²	
Energy conservation measures	Investment [USD]	Net saving		Payback [year]	NPVQ *
		[kWh/yr]	[USD/yr]		
1. Energy efficient showers	400	2 300	200	2,0	2,51
2. Sealing of windows	10 000	78 000	7 800	1,3	2,20
3. Operation and maintenance manuals / Energy monitoring system	15 000	54 050	4 400	3,4	1,06
4. Insulation of attic floor	12 500	17 480	1 750	6,9	0,73
5. Balancing of heating system and thermostatic valves	22 500	53 800	5 400	4,2	0,69
6. Insulation of pipes, valves etc.	9 500	14 950	1 500	5,3	0,43
7. Heat recovery, ventilation system	25 000	37 000	4 650	5,4	0,31
8. Automatic control system	20 000	39 790	3 480	5,7	0,22
Total ENCON measures	114 900	311 890	29 180	3,9	

*) Real interest rate 7 %

***) All examples in this book are based on buildings situated in the capital of Norway, Oslo

If the implementation of all the measures (and investments) in one project is too expensive, then they can be carried out through two projects commencing with the most profitable (the top of the list). For instance, the first five ENCON measures could be implemented in the first project, and the following year a second project could fulfil the rest of the measures.

5.1 Renovation and improved indoor environment

In addition to the implementation of ENCON measures, a general renovation of the building and improvements to the indoor environment is often required. It is very important that all necessary measures are evaluated and included in one project:

- Energy conservation
- Renovation
- Improvement of the indoor environment

In this way, the renovation and improvement of the indoor environment could be implemented in an energy efficient way. The result of a combined energy audit is illustrated in the following table.

Tab. 3 Energy Audit Report - ENCON and renovation potential

ENCON Potential – Energy Audit					
Building: ENSI® Head Office, Oslo		Project no: 10130		Heated area: 2 300 m ²	
Energy conservation measures	Investment	Net saving		Payback	NPVQ
	[USD]	[kWh/yr]	[USD/yr]	[year]	*
1. Energy efficient showers	400	2 300	200	2,0	2,51
2. Sealing of windows	10 000	78 000	7 800	1,3	2,20
3. Operation and maintenance manuals / Energy monitoring system	15 000	54 050	4 400	3,4	1,06
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8. Automatic control system	20 000	39 790	3 480	5,7	0,22
Total ENCON measures	114 900	311 890	29 180	3,9	
9. New windows	155 000	129 490	12 950	12	0,04
10. Insulation of external walls	185 000	90 390	9 040	20,5	- 0,39
11. New light fittings	43 000	22 500	2 900	15	- 0,39
Total all measures	487 900	476 270	46 270	10,5	

*) Real interest rate 7 %

In this example, the list of measures is the same as in the Scanning Report, but investments, savings and profits are listed separately for each measure. They have also been ranked based on the profitability.

New windows are normally an unprofitable ENCON measure, but if the windows are in poor condition, broken (renovation measure) or with high infiltration (ENCON and indoor environment measure), then it is necessary to include this measure as a part of the ENCON project. The new windows should be as energy efficient as possible (low U_{window}). The increased investments compared to the increased savings (lower U_{window}), would often have a high profitability. If the facade is damaged and must be repaired (renovation measure), it is usually profitable to combine the reparation of the facade with additional external insulation.

6 Business plan

If the various ENCON and renovation measures cannot be financed by the owner's own resources, external financing (loans) are needed. To acquire loans for big projects, especially from international financing institutions, it is necessary to develop a business plan.

The main chapters in a standard business plan are:

- Executive Summary
- Borrower
- Project Information
- Environmental Benefits
- Market
- Financing Plan
- Financial Projections
- Project Implementation

For smaller projects, and for projects to be financed by national banks/financing institutions with special arrangements for ENCON projects, it is often enough to include a standard chapter of "Financing" in the Energy Audit Report. Often ENCON Funds have prepared standard application forms, which can be completed by information from the energy audit report.

7 Implementation

Once the Energy Audit has been presented to the building owner and the financing has been arranged, the contracts for Implementation can be signed.

The implementation phase includes the following activities:

- Project organisation
- Design/planning
- Contracting
- Installation
- Control and testing
- Commissioning
- As-built documentation
- Training of personnel

8 Operation and maintenance

The building should be operated and maintained by trained personnel. Unskilled personnel, lack of appropriate operation and maintenance routines, etc. leads to an increased energy consumption in the future, despite the installed ENCON measures.

The activities that are carried out in a hospital are different from the activities in an office building, thus the operation and maintenance requirements will also be different.

In order to minimise the energy consumption in a building, the technical installations must operate in a correct way. This can only be accomplished by skilled operational

personnel, continuous inspection (manually or by computers) and systematic maintenance. By the execution of a regular maintenance programme, large and expensive repairs and secondary costs from the operation could be avoided. The working environment and indoor environment are also improved by continuous maintenance.

Operation and maintenance of a building should be based on some general requirements:

- The personnel must have the skills and motivation required for the job
- The responsibility for operation and maintenance should be distributed, so that everyone knows the responsible person/persons for maintenance, the energy and power demand budgets, etc.
- The complete documentation for operation and maintenance of the building and the technical systems should be available and well organised
- Suitable work and time organising tools (manual, job cards or computer based systems) should be used

9 Energy monitoring

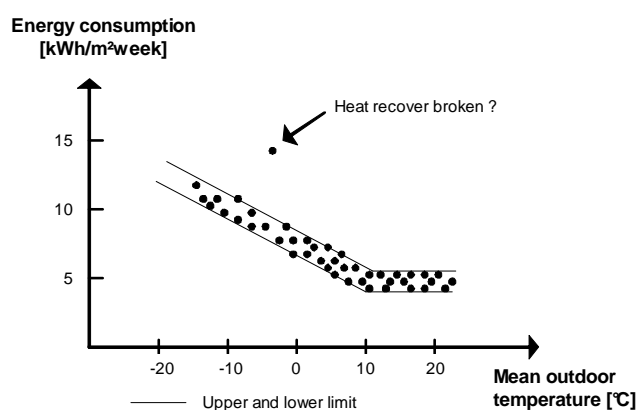
Energy monitoring devices are important tools for systematic and continuous control of the operational conditions and of the energy consumption.

Every building has its own, unique ET-curve.

By computer calculations, the reference curve can be established. This ET-curve shows the necessary energy consumption for different outdoor temperatures, assuming **correct** operational conditions.

When the ET-curve of the building is established, an upper and lower limit can be defined on the curve. Normal variations caused by fluctuations in sun load, wind or normal variations in the operating conditions are within these limits.

If the measured energy consumption of the periodic registration is outside of this limit, the operation and maintenance personnel should investigate and be able to find the reason and make the necessary corrections. For ease in identifying the reasons for the deviation, a deviation checklist is provided.



Introduction of energy monitoring in a building would enable the operation personnel to:

- Correct the operation of technical equipment
- Detect the errors/breakdown of technical equipment
- Reduce the energy consumption
- Document the results from energy conservation measures

10 EAS v1.0

Software EAS v1.0 is created from the results of the Key Number Software according to the Key Numbers Methodology, level 3. The database contains 42 standardized dwelling houses and 8 typical family houses.

The dwelling houses are integrated into four categories according to their years of construction and construction of the building envelope.

It is very difficult to determine the properties of the building envelope of the single family houses. Therefore are the family houses typed by changing our national standards (called CSN) valid in the past, which defined the physical requirements of the building envelopes.

Software EAS v1.0 provides a completely manual for energy auditors as well as for building contractors of reconstruction works on existing buildings. By the expertise of the selected type of dwelling or single family house is the structure of EAS v1.0 following:

- Photo documentation
- Drawing documentation
- Building description
- Energy – economy calculation
- Graphical presentation
- What is an energy audit...

In the application are implemented tree basic domains of energy measures:

Tab. 4 Energy saving measurements of Building Envelope

Prof.	Application of measure	Energy saving measures
BE	Building Envelope	Insulation of external walls
		Insulation of floor or insulation of unheated basement
		Insulation of roof
		New windows

Tab. 5 Energy saving measurements of Heating System

Prof.	Application of measure	Energy saving measures
HS	Heating System	Automatic control system and temperature set back for HS
		Insulation of pipes, valves,... on the HS
		Reconstruction of boiler room (new boiler, accessories,...)
		Balancing of the HS and installation of thermostatic valves

Tab. 6 Energy saving measurements of Hot Water

Prof.	Application of measure	Energy saving measures
HW	Hot Water	Water saving shower heads
		Thermostatic mixer, showers
		New automatic control system on the HW
		Insulation of pipes, valves,... on the HW

According to the calculations and realized projects of energy saving measures on existing buildings is the contribution percentage of energy potential following:

Tab. 7 Energy potential for individual energy saving measures*

Profession	Measures	Percentage of energy saving possibilities
BE	Building Envelope	20 - 30 %
HS	Heating System	10 - 25 %
HW	Hot Water	5 - 10 %

In the application are dynamically calculated the costs of energy saving measures which depends on the cost of GJ heat or m³ of natural gas. It is possible to select two ways how to input the proper cost of energy according to the energy supply of existing buildings.

When the building is connected to the centralized heating system you need to input the price of GJ heat into the dialog window. The default price is based on the actual price list of the Department for Regulation of Network Sector in Slovakia as well as you can put the actual price of heat from various heat suppliers. This way is eligible for dwelling houses.

When the building is connected to the centralized distribution of gas you need to input the price of m³ of natural gas. The default price is based on the actual price list of the Slovak Gas Company – SPP in Slovakia as well as you can put the actual price of m³ of natural gas according to another tariff rate. This way is eligible for single family houses and decentralization of dwelling houses.

The application contains two differentiation of energy saving calculation. The first one allows you to calculate the whole building and the second is eligible for calculation of one flat from the building. The calculation for one flat contains energy saving measures applicable separately. It means that the owner of the flat can realize the measures individual (new windows, thermostatic mixer,...).

Results of the energy calculation are shown in kWh/year and GJ/year. An important part of the development of any project is the evaluation of its profitability. We used the payback method which is the most handy tool for quick calculations. The necessary investments for the profitability calculations are running behind and contain the costs for supply, design work, installation, tests (pressure, running,...), other expanses and taxes (VAT). These investments will be updated by price changing.

11 Conclusions

The accuracy rate of energy audit depends on the design level. To achieve the high accuracy of an energy audit, precise energy and economic calculations are essential. Accurate calculations require correct input data and adequate calculation tools (software), which lead to a more time-consuming project development.

We know many methods of energy demand calculation for example CEN 832 on which is based the Key Number Software as well as we used it for our application. Reducing of input values and an easy handiness was required because the application was developed for purposes of the First Building Society Savings Bank - PSS a.s. in Slovakia. Software EAS v1.0 is therefore accurate enough for a lay public with an accuracy of ±10 to 20 % (it cannot replace advanced computer-based energy evaluations when making detailed studies).

References

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- [4] REPKA N. EAS v1.0 application manual

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