Energy Efficient Refurbishment of Hospital Buildings in Hungary

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According to the Hungarian decrees (7/2006 TNM and 40/2012 BM) in case of substantially renovated buildings, the specifications given for the doors and windows, slabs, walls, and floors have to be met, besides, the overall energy characteristics of the building must be below the specified value. The required figures of overall energy characteristics are specified for residential and accommodation-type buildings, office blocks, and educational buildings; buildings of other purposes belong to "other" category. There are no specific requirements for healthcare facilities, thus, the energy consumption of healthcare institutions, and the energy characteristics of some specific buildings of this type have to be surveyed by taking the requirements of the relevant Hungarian decrees into consideration.

The procedure of preparing an energy audit and assessment

The procedure includes the following:

- establishment of the requirements;
- identification of energy-consuming systems;
- establishment of actual energy consumption;
- comparison of actual energy consumption and the designed figures;
- proposing energy-saving measures.

The tasks of energy audits and assessment do not include exact cost-and-return-on-investment calculations since they would require asking for quotations, which belongs to the scope of feasibility studies. However, all energy audits are required to include calculations with at least approximate precision which help the owners or decision-makers decide which investments to launch or else which investments require the accomplishment of feasibility studies.

The aim of energy audits, therefore, is to survey the energy consumption of the buildings concerned, and proposing energy-saving initiatives for refurbishment. However, as it is specified in EU directives, indoor environmental requirements have to be taken into consideration for energy-saving measures. Concerning the air supply of healthcare institutions, the Hungarian standard is suggested by MSZ 03-190:1987 can be taken into account. In case of and public spaces and offices, the CEN report CR 1752 and standard EN 15251 are applicable.

As for the institutions surveyed, energy assessment has been carried out according to the following steps:

1. Identification of the buildings to be surveyed within the scope of the audit. Establishing the internal requirements (according to the data available or the function of the premises concerned).
2. Collecting the design documentation available (architectural and engineering implementation-plans, implementation plans of electrical network designs, technical specifications etc.).
3. Identification of power-supply systems, and areas of consumption. Clarification of the site-plan.
4. Collecting the utility and maintenance contracts, data of energy consumption (settling bills) concerning the previous 3 years.
5. Preliminary site survey, discussions with building operators and technical staff, recording operating experience.
6. Establishing actual consumption data according to the available bills. Analysis of consumption data, determination of average energy-consumption characteristics by taking heating degree-days into consideration, assessment of committed quantities. Analysis of energy cost, establishment of the actual-consumption-dependent and independent cost proportions.
7. On-site survey of building envelop and the associated HVAC and lighting-technology systems, field measurements (parameters of indoor climate, circulation time of DHW).

8. Assessment and summary of the results of the on-site measurements.
9. Heating-technology sizing of the buildings, according to the actual function of the premises (rooms), the current internal environmental requirements, and the current status of the building structure.
10. Determining the actual primary energy demand of the HVAC systems.
11. Comparison of the actual and design figures, exploring the reasons for any differences.
12. Proposing energy-saving measures. Assessment of the energy impact of the proposed initiatives according to the expected changes in specific heat loss figures, and the primary energy demand of HVAC and lighting-technology systems.
13. Analysis of payback times according to specific investment costs.

Evaluation of energy saving measures

The heating-technology sizing for the individual buildings and the establishment of primary energy demand of HVAC systems, and the analyses of the energy impacts of energy-saving measures have been carried out by means of the Hungarian WinWatt design software.

We have elaborated the energy-saving measures concerning building-structure renovation, and modernisation of HVAC systems and the electric network. The building-structure refurbishment in general includes the replacement or modernisation of doors and windows, and the external thermal-insulation of the building concerned.

Modernisation of the heating system, by all means, shall include the replacement or renovation of outdated heating systems, hydronic balancing, installation of radiators with thermostatic valves.

Concerning water supply, by installing water-saving faucets, toilet tanks, and urinal rinse tanks, the amount of water used and thus the total operation costs can be reduced. In case of healthcare facilities, prevention of legionella infection is particularly important. This can be achieved by providing sufficient DHW, and establishing suitable hot-water systems (by the elimination of stagnant water-line sections, and providing satisfactory circulation).

The modernisation of electric networks includes the replacement of the existing lighting system with energy-saving alternatives. When replacing the fluorescent lamps, the transition to modern electrical ballasts is also advisable. Additional savings can be realised by installing motion-detector lighting design, where it seems appropriate. It is generally recommended to check the efficiency of the electric-power-consuming machinery and equipment, and to replace the outdated ones. Thereby inductive idle power is also going to be reduced, implying further cost saving. A further option, in order to reduce reactive performance, is offered by installing multiple power factor correction units. In this case, the instrumental analysis of the impact of the performance to be compensated to the network, and, if necessary the installation of filter-circle power factor correction units are recommended.

In addition to the above, in order to rationalise energy consumption, it is always recommended to provide energy training to the staff, users and operator in order to realise energy-conscious behaviour.

Technical systems in case buildings

In case of the institutions involved in the study, a total of 18 buildings and the related HVAC systems and lighting systems have been assessed, predominantly according to their primary energy consumption. The buildings are located in Hungary, Gyor [2] and Derecske [1].

The structure of the dominantly brick-masonry buildings were seriously deteriorated. With the exception of some buildings no significant renovations have been completed, only on-going repairs and facade renovations have been implemented. Consequently, in the majority of the buildings most of the problems have been implied by the outdated windows and roof structures. (In relation to this, in the buildings concerned draught problems have been experienced almost constantly.)

The heating and domestic hot water supply, with one exception, is provided by the district-heating network. Natural gas and steam are used for technological purposes only. The heat emitters of the buildings are usually cast-iron radiators, typically installed without thermostatic radiator valves. The pipe networks are of mixed design (one-pipe without bypass, one-pipe with bypass and two-pipe systems).

On the secondary side pumps with constant speed were installed. In many cases the control on the second side does not function adequately, therefore, manual control is applied. The hydronic balancing of the systems have not been accomplished, the relevant valves needed for it are missing. In several cases, technological heat usage is wasteful.

Table 1. The thermal energy use of buildings according to the survey.
Q_{tr} [kW] = total heat loss of the building
q_{calc} [W/(m³K)] = calculated specific heat-loss coefficient
q_{all} [W/(m³K)] = allowed value of specific heat-loss coefficient
q_h [kWh/(m²a)] = net thermal-energy value of heating
E_h [kWh/(m²a)] = primary energy demand of the heating system
E_{DHW} [kWh/(m²a)] = primary energy demand of the DHW system

	Characteristics of the present state								
	Premises	V [m³]	Q_{tr} [kW]	q_{calc} [W/(m³K)]	q_{all} [W/(m³K)]	q_{calc}/q_{all} [%]	q_h [kWh/m²a]	E_h [kWh/(m²a)]	E_{DHW} [kWh/(m²a)]
Derecske	**Paediatric surgery**	1059	47	0,857	*0,454*	*189%*	235,0	298,8	14,7
Gyor	**Híd-street site**	8680	252	0,592	*0,304*	*195%*	183,4	222,1	47,1
Győr, Magyar **Street**	**Building"A"**	44152	1009	0,319	*0,200*	*160%*	84,3	118,4	48,2
	Building"B"	36241	701	0,257	*0,244*	*105%*	77,4	109,9	48,2
	Building"C"	29273	833	0,411	*0,200*	*206%*	119,4	160,8	48,2
	Building"E"	29839	748	0,417	*0,223*	*187%*	113,9	154,3	48,2
	Clinic	9968	267	0,414	*0,245*	*169%*	114,0	154,8	48,0
Győr, Zrínyi Street	**Nursing ward "A"**	3119	88	0,385	*0,219*	*176%*	106,4	137,0	46,2
	Nursing ward "B"	4664	122	0,479	*0,242*	*198%*	95,7	124,4	45,8
	Dermatology	2428	76	0,531	*0,287*	*185%*	109,6	140,9	46,2
	Psychiatry block	17637	468	0,356	*0,237*	*150%*	126,4	158,1	45,4
	Infectology	3402	113	0,450	*0,200*	*225%*	126,1	159,1	46,2
	Isotope diagnostics	4548	120	0,482	*0,220*	*219%*	95,1	123,6	45,8
	Laboratory, pharmacy	4563	128	0,438	*0,273*	*160%*	136,5	170,5	45,8
	Oncology	8790	183	0,279	*0,200*	*140%*	78,9	104,8	45,8
	Morgue	956	40	0,785	*0,315*	*249%*	138,3	175,7	48,1
	Pulmonology	7283	200	0,507	*0,235*	*216%*	154,9	191,1	45,8
	Lung screening	2160	67	0,486	*0,271*	*179%*	102,2	132,6	46,6

The faucets are traditional and single-lever mixing design. The flush of the toilets are of mixed types; it is either supplied by upper flushing tanks, or, in the renovated toilets, (about 15%) there are flushing tanks equipped with flush-stop function. Domestic hot water is circulated in the majority of the buildings, however, according to users' complaints, circulation is insufficient. This was justified by on-site measurements as well. The electric systems of the buildings were installed predominantly in the seventies, and they represent the technological standards of the era concerned. The estimated average age of lighting systems can be between 20-30 years, in most cases they are outdated and fail to meet the modern-day standards. In some specific buildings, energy-effective (and reliable) operation is hindered by 20-30-year-old distributor-fuse equipment. Meanwhile, the gradual replacement of lighting units to modern mirror-reflection energy-efficient versions began in the recent years.

Results of the energy audit and assessment

In the following the assessment of energy saving initiatives and their estimated effect are presented.

- Installation of thermostatic radiator valves and their adjustment.
- Replacement or modernisation (by replacing their seals and by applying the so-called Duplo-Duplex method) of doors and windows.
- Decrease of filtration by the alteration of internal space connections.
- Subsequent external thermal insulation (walls and slabs).
- Complete thermal insulation of the building (Subsequent external thermal insulation and replacement or modernisation of doors and windows.

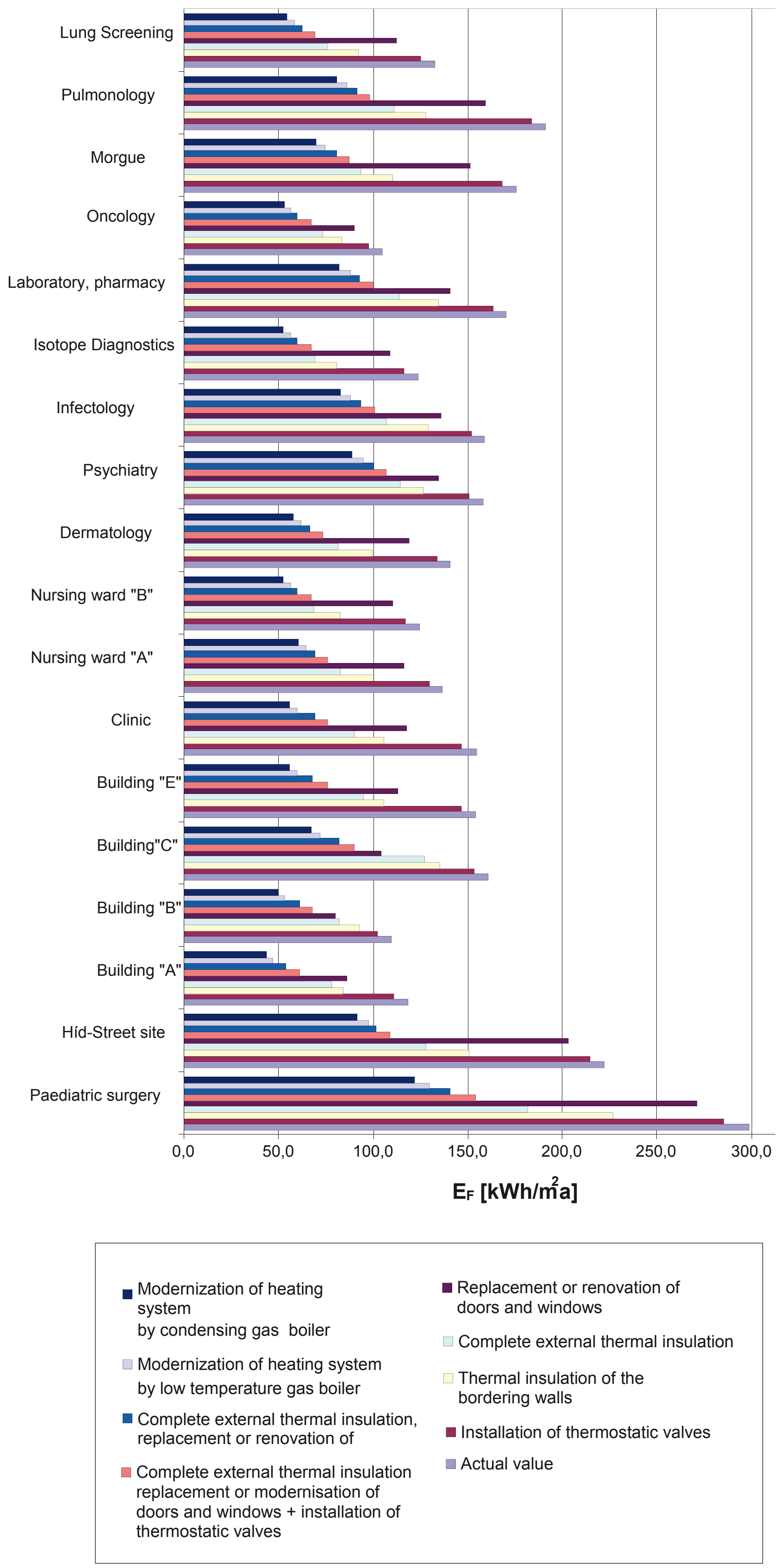

Figure 1. The calculated impact of energy-saving measures on primary energy demand of heating systems.

- Complete thermal insulation of the building and modernisation of the heating system (exchange of radiators, installation of thermostatic radiator valves, balancing valves and balancing the heating system).
- Complete modernisation with individual gas boiler (total thermal insulation of the building and modernisation of the heating system, installation of individual gas boiler with control by outdoor temperature and variable speed pumps).
- Complete renovation with individual condensing gas boiler total thermal insulation of the building and modernisation of the heating system, installation of individual gas boiler with control by outdoor temperature and variable speed pumps).

Remark: In case of hospitals with several pavilions this solution does not make management with state-of art technology possible or the application of alternative fuels. It can be a good solution in case of clinics.

Table 1 shows the actual energy consumption of different parts of the hospital. Based on the calculation different measures were suggested. The estimated reduced energy consumption in primary energy demand is presented in the **Figure 1**.

Conclusion

The article presented the possible energy efficient refurbishment in Hungarian hospitals. The current energy consumption is show in the table. The effects of the energy saving options are presented in **Figure 1**. Based on this study the energy efficient refurbishment has started and will be completed soon. A few years later the real energy consumption will be compared with the calculated measures.

References

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