CONDITION CONTROLLING AND MONITORING OF INDOOR SWIMMING POOLS

Nissinen, Kari, VTT Building and Transport, PO Box 18021, FO-90571 Oulu Finland, Kauppinen, Timo, VTT Building and Transport, Hekkanen, Martti, VTT Building and Transport

Summary

VTT has executed a lot of research work concerning the usage, functionality and refurbishment of indoor swimming pools and spas lately. This work includes for instance detailed condition surveys, energy audits, cost analysis and maintenance planning tools. The prevailing conditions make special demands for planning, constructing, repairing and maintaining the indoor swimming pools. Main topics are usually connected with shortening of the service lives of the building parts and technical installations and the indoor air quality. Also the yearly running costs can be remarkable high. VTT has created the technical risk map for indoor swimming pool repairs. This risk map presents the most significant factors that must be taken into account in order to repair facilities successfully. Due to optimizing the operation and maintenance VTT has developed operation and maintenance manual software that is specially targeted for indoor swimming facilities. This paper presents the technical risk map, the condition survey procedure, the energy saving methods and the maintenance record book for indoor swimming facilities to secure the success of a refurbishment project.

Keywords: swimming halls, indoor spas, condition survey, energy audit, cost analysis, technical risk map, operation and maintenance manual, software

INTRODUCTION

There are about 250 indoor swimming pools and 50 indoor spas in public use in Finland. Typically, the indoor swimming pools are owned by the local community. The public services of the community are in charge of maintenance and operation. Normally in the communal organization there is a department for property and facility management (maintenance) and a section for sports and recreation (operations). The spa and wellness centers are usually in the private ownership. Generally the owner is a real estate investment company, maintenance is outsourced and the operations and spa business are run by specific hotel company.

These facilities are very expensive to construct, operate, maintain and repair. Comparing to other typical Finnish sports buildings the life cycle cost per square meter of swimming halls is high (figure 1). For instance the energy and facility maintenance costs represent typically 15 per cent of the total turnover of indoor spa and wellness centers. In swimming halls (public use) communal subvention is needed therefore the incomes cover only the energy and maintenance cost.

The energy consumption level of the swimming halls and spas is remarkable high (figure 2). The total energy consumption is as high as 100-150 kWh/m3 per year. Compared to the office and school buildings the consumption figures of swimming halls and spas are almost double. Typical Finnish office building needs 30-40 kWh/m3 heating energy per year and consumes 25-30 kWh/m3 electric power per year. The heating energy consumption of schools varies between 30-60 kWh/m3 per year and the electricity consumption between 10-15 kWh/m3 per year.

The replacement value of these 300 buildings is high, approximately 1, 8 billion €. It is obvious that a systematic maintenance and caretaking of these costly buildings can save great sums of money. Considering the environmental aspects it is also very important to manage and operate these kinds of facilities in as efficient way as possible.

According to the study /3/ the service life of typical Finnish swimming hall is relatively short. Most of the indoor swimming pools and spas have to be repaired exhaustively after 20-30 years of use. Not later than just after 20 years the service lives of many important structures, equipments and building service systems have came to the end of their functionality. On the other hand also the user demands change upon time. Nowadays people except to get more varied and versatile experiences and services than before. To keep the customers satisfied it is not enough to repair a building - in many cases total refurbishment is needed.

A significant share of Finnish swimming halls has been built in late 70’s and 80’s. Today this building stock is at the age where large scale renovations and refurbishments are needed (figure 3.).

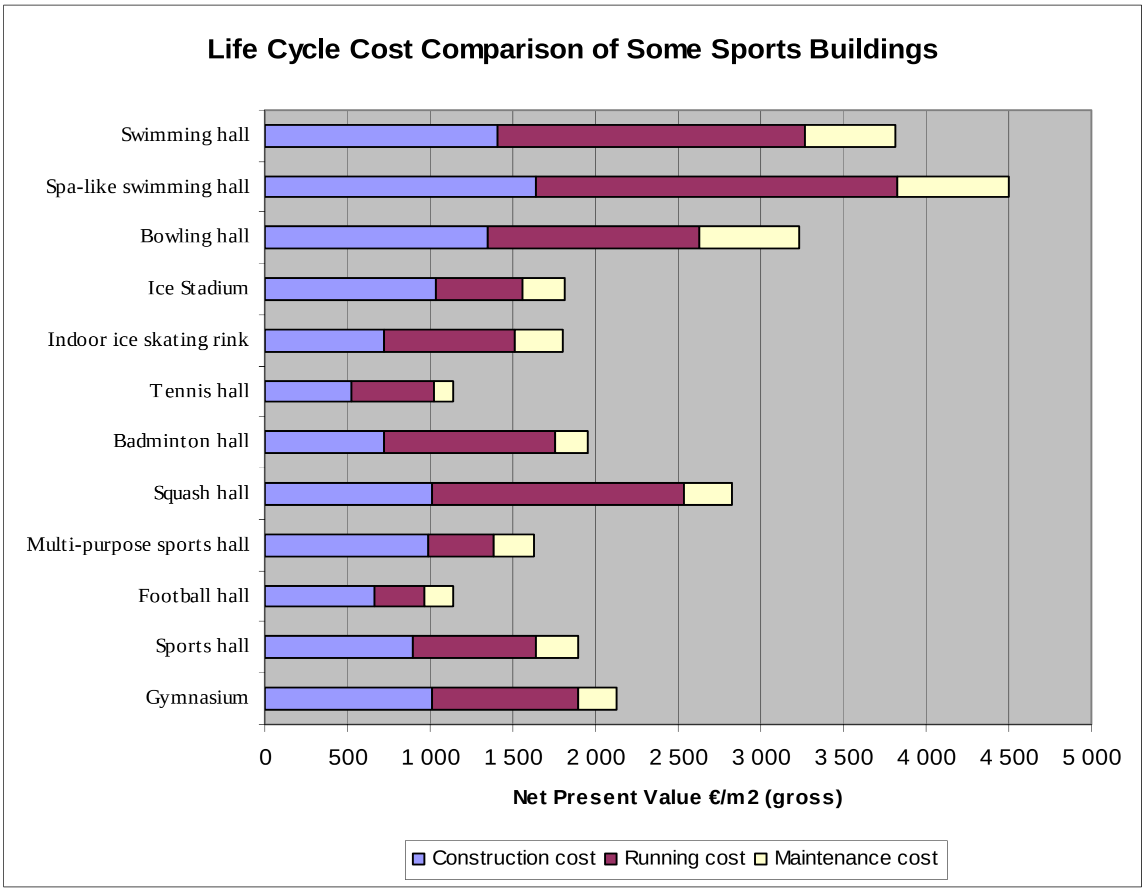

Figure 1. Life cycle cost per square meter of some typical sports buildings in Finland. Period under review 30 years and interest rate 4%. Costs on the year 2004 cost level. /2/.

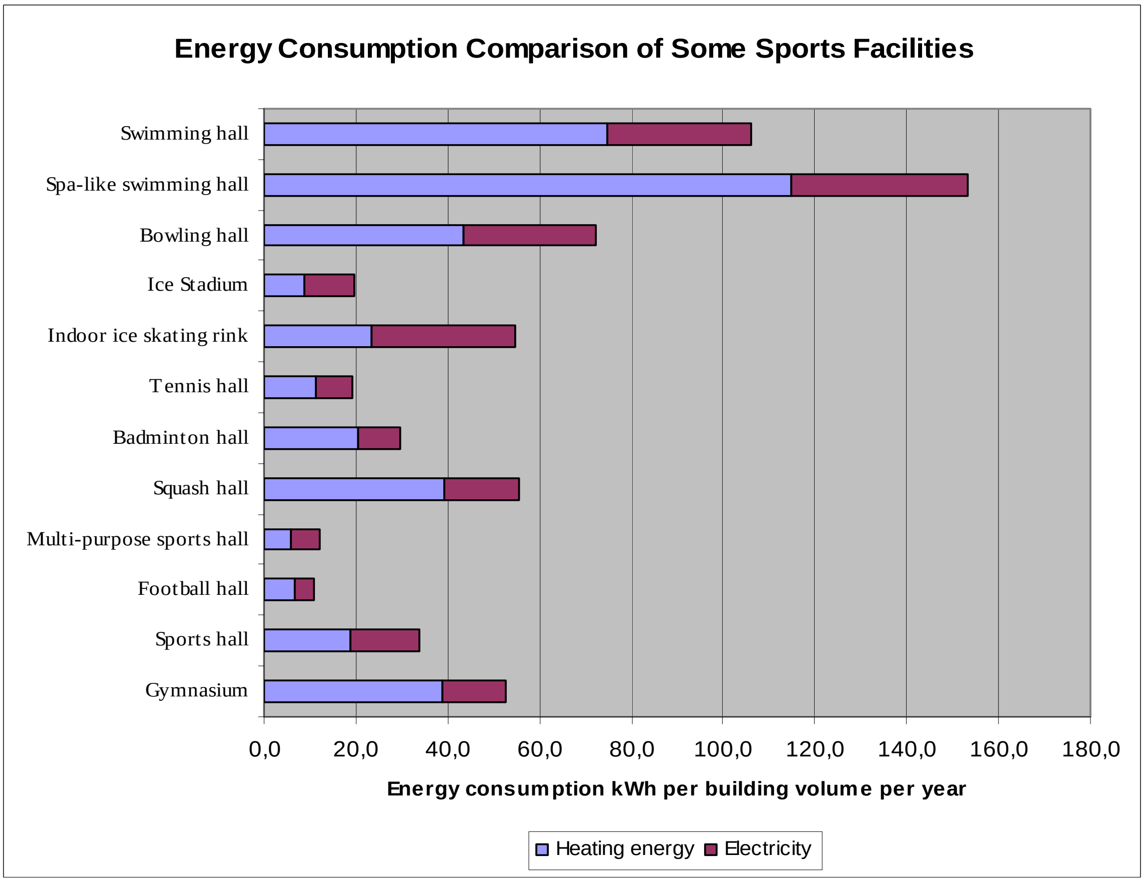

Figure 2. Normalized (weather-corrected) energy consumption per building volume of some typical sports buildings in Finland /2/.

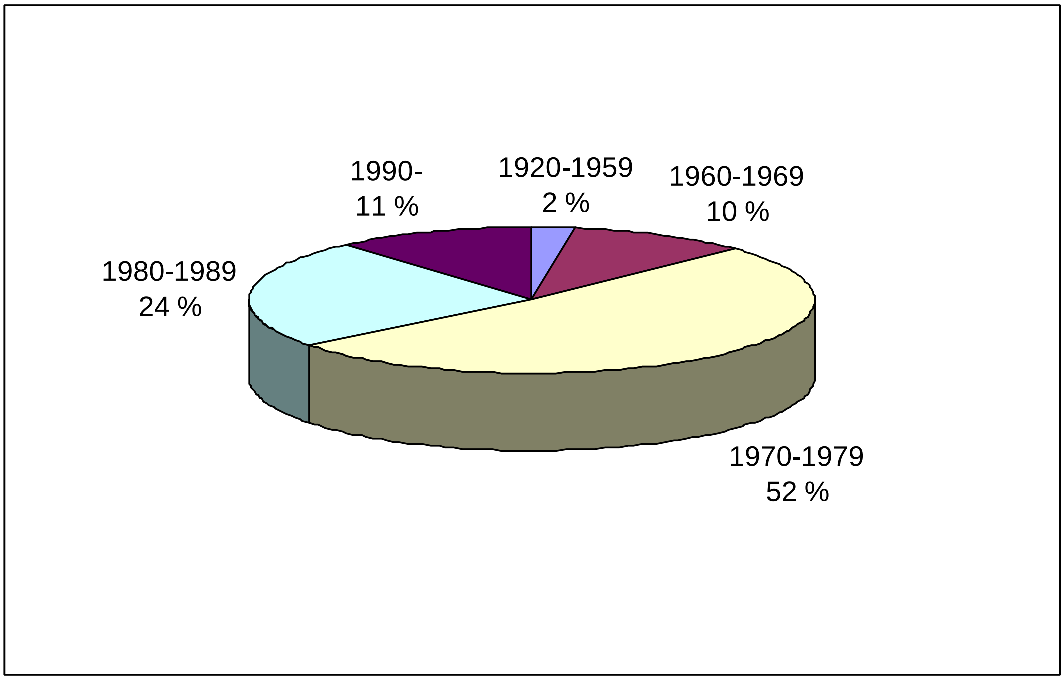

Figure 3. Distribution of Finnish swimming halls and indoor spas in public use according to the decade of construction /1/, /3/.

DAMAGES, NEEDS OF REPAIR AND TECHNICAL RISK MAP

In the study /3/ we analyzed 17 swimming hall renovation projects. Thoroughness of the repair work in these projects is shown in table 1. In most of the projects building service systems were either totally replaced or significantly repaired. The average renovation cost of these projects was app. 900 €/m2 (gross) that is about 60% of the average replacement value of these swimming halls. After refurbishments these swimming halls attracted customers much better way than before. Number of the yearly visitors grows up on average of 35% comparing to the time before the renovation project. We also found out that it is possible to reduce energy consumption remarkably by skillfully planned and executed renovation methods.

During the last 15 years VTT has analyzed dozens of swimming hall renovation and refurbishment projects. On the basis of these observations we have created technical risk map to help renovation developers, designers, contractors and managers to concentrate on these topics in order to make sure that the typical mistakes can be avoided. Some of the technical risk factors by building part or service system are shown in table 2.

Table 1. Distribution of 17 swimming hall renovation projects according to the thoroughness of the repair work by building part or building service system.

Building part/system	Not repaired	Significantly repaired/partially replaced	Totally replaced
External walls, facades	18 %	**70 %**	12 %
Roof	59 %	29 %	12 %
Ceramic tiles of pools	29 %	29 %	42 %
Ceramic tiles of circulation space	29 %	18 %	**53 %**
Surface structures of dressing- and washrooms and saunas	0 %	35 %	**65 %**
Surface structures of other spaces	6 %	29 %	**65 %**
Heating and ventilation systems	12 %	**59 %**	29 %
Water service systems	6 %	**59 %**	35 %
Water treatment systems	12 %	29 %	**59 %**
Electric power and information systems	12 %	**59 %**	29 %

Almost without exception the repair works are started without careful condition survey of the building. When reaching for a successful result one of the most important requirements is the selection of the designers. Usually the best designers can not be gotten with the lowest price. However investing on the design quality will usually generate big savings during the lifetime of a building. The same rule is also valid for the selection process of constructors. Only in a few renovation projects enough attention is paid to training of the maintenance personnel. Too many facilities are opened up for the customers too hastily just after the last renovation works have been completed. In most cases there is not enough time for maintenance staff to learn how to operate the brand new building service systems. It is not unusual that a very expensive and demanding building is operated without systematic service instructions and without any systematic maintenance record book.

Table 2. Some vital technical risks in swimming hall renovation project.

Building part/service system	Technical risk
Roof and external walls	1. Poor leak-proof of moisture barrier. Risk for remarkable and large scale moisture damages. 2. Defective airing/ventilation of the structures. Risk for remarkable and large scale moisture damages. 3. Not enough attention to the local climate conditions. Risk for failure of important building service systems, freezing etc. 4. Thermal bridges. Risk: direct and indirect (lower surface temperatures compensated by higher indoor temperature) increase of energy consumption, lower thermal comfort, draft problems, moisture defects by condensation.
Swimming pool structures	1. Poorly made joints and sealing. Risk for water leakage. 2. Wrong working methods, wrong fixers and defective after-treatment of swimming pool ceramic tiling. Risk: tiles loosen away. 3. Wrong steel material, wrong treatment of steel structures. Risk: rust, short service life.
Surface structures	1. Wrong surface materials taken into consideration the space use. Poor compatibility of surface materials, fixers and underlayings. Risk: poor safety, rust, short service life, hardness to keep clean. 2. Poor inclination of the floors. Risk: constantly water on the floor.
Water treatment systems and water fittings	1. Replacing system partially. Risk: service life of the not-replaced parts end (it is hard to predict the service life of some special components). 2. Poorly made breakthroughs for water fittings and decorations like fountains etc. Risk: Water leakage to structures. 3. Choosing the wrong location for water fittings. Risk: Water leakage to structures.
HVAC- systems	1 Choosing too complicated systems to control the pressure conditions inside the building. Risk: Positive pressure drop between humid spaces and outdoors or not-humid spaces. Risk for remarkable and large scale moisture damages. 2 Wrong placement or wrongly maintained heat recovery system. System freezing. Failure, malfunction, moisture problems. 3 Poor isolation of those ducts that are colder than surrounding environment. Risk: Condensation of the water vapor; moisture defects.

CONDITION SURVEY AND ENERGY AUDIT PROCEDURES

The prevailing condition of swimming hall can be considered e.g. base on the following classification:

1. Operational condition
2. Technical condition
3. Economical condition

Operational condition of the facility is good if the use of the hall still satisfies the requirements of customer service, many years after it has been completed. Technical condition is the factor that generally launches the renovation. When the technical condition degrades to the level the hall can not be run by reasonable costs. The customers pay attention to both physical and also visual conditions. Good economical condition requires the proper economical facts. The economical analysis must be based on life cycle procedure in which the maintenance and renovation costs have been taken into account. It is possible to increase the performance level equal to the recent requirements by refurbishments. Without resource limits we could develop the facility over that level.

Based on the condition survey we can determine the technical performance, remaining service lives and the possible needs of repair of the structures and building services. The condition survey needs special expertise and special devices. The methods can be divided into destructive and non-destructive methods. Such methods are for instance:

- measuring the depth of the reinforcement of the concrete
- temperature measurements
- thermal scanning
- air flow measurements
- indoor air quality measurements
- performance test of the equipments
- analyzing the wall thickness of water and heating pipelines by ultrasonic meter
- energy consumption analysis
- samples of concrete structures, paints and asbestos (laboratory studies)
- other samples from water and sewage pipelines
- scanning of sewage and ducts by remote controlled video camera.

The measurements can be divided into

- condition measurements (ventilation, air flow, moisture, temperature, pressure drop)
- these measurements can be
    - continuous measurements (2-8 days) and single measurements
- concrete structure measurements
- water treatment measurements
- HVAC-systems
- energy studies

The condition assessment procedure can be divided into the following three categories:

- the basic condition assessment (light, mainly walk-through type of study including the checking of documents and reports available)
- the condition assessment (incl. also monitoring and measurements)
- the detailed condition measurements.

The cost of the condition assessment depends on the chosen scale and level of the measures. A roughly estimation is that the light survey cost represents 0,4% and the detailed condition study represents 1,2% of the repair cost.

The energy audit is based on the procedure created by MOTIVA that is public organization under Ministry of Trade and Industry. MOTIVA controls the energy audits in Finland. Before energy audit a benchmarking study can be carried out - comparison between the analysis target and the statistics (figures 4-6), based on the results of benchmarking, one can make conclusions if energy audit is needed or if only some targeted measurements or checking's must be done.

The energy audit cost is determined by MOTIVA and it is based on the cubic volume of the building, the existing energy and water costs and the type of building. For instance for the 50 000 m3 swimming hall the acceptable energy audit cost is 10000 € of which 40-50% can be subsidized by MOTIVA.

The energy audit includes the following steps/6/:

The evaluation of the present state of the energy use

1. Starting meeting

The energy audit will be launched by starting meeting, in which the representatives of the target and the energy auditors agree on the details and the focus of the realization. The following topics dealing with the audit will be agreed:

- Mapping the goals and the needs of the customer
- The timetable of the realization
- Contact persons and contact information
- Movement and traffic inside the target building
- Limitations for the field work
- The special needs for the audit and reporting

2. Collection of the initial data

Before the start of field works the initial data will be collected. Based on this information we create an overall view from the energy economy of the target and from the probable saving objects. The field work and the measurements will be planned. The initial data includes

- energy and water consumption in 3 - 5 years period
- design-, operation- and maintenance records
- the studies and surveys done in the target

3. Field work and measurements

During the field work all the energy production-, transfer- and supply devices and all the systems consuming heat, fuels, electricity or water will be charted. In this charting all essential technical information and specifications of the systems and equipments will be registered. Also the possibilities to improve the energy economy of the target by different use, by repairs and investments or by purchasing new equipments must be evaluated. The goal of the field work is to find out all the measures with less than 10 years payback time, by which the use of energy or water can be reduced, intensified or recovered.

To map the saving potential we must have adequate amount of measurements. The following measurements must be carried out in all the targets:

- Ambient indoor temperatures by adequate samples (the average indoor temperature, temperature levels and stability, considering the impact of external and internal loads)
- The flow of water fittings (to determine the saving potential)
- The efficiency of the ventilation heat recovery units, by accuracy we can check the possible deviations from the normal or planned level
- The supplied air temperatures in normal conditions
- The efficiency of boiler unit, the calculation of annual coefficient of efficiency is recommendable
- The lighting level in typical rooms
- The ratio of the night-time and day-time electricity
- In the audit targets in which the labor costs of the audit exceed a certain sum, the active power must be measured during a day, or during a week period including working days and weekend

Analyze of the saving potential

The distribution of the water and energy consumption will be evaluated according to each system and also according to biggest single consumers that we could ensure the right magnitude when counting savings. Based on initial data, on the observations and measurements carried out and on the interviews of the user's one can analyze the level of the energy use and saving potential of the target.

The savings to be achieved and also needed investment costs will be calculated for the energy saving measures found. The realistic and valid measures must be prepared for the report in a way that the customer can make decisions for investments or further planning. The suggestions must cover the requirements for indoor air quality and working environment. Table 3 shows the saving potentials of some audited building types.

Proposals for actions and reporting

The essential part of the energy audit is to introduce the result clearly in the form of a compact written report. The proposal for actions and the savings potentials must be presented in illustrative tables. The budget of the proposed actions must be presented, as well as an evaluation of the effects for the energy, water and costs savings and the payback-time.

The energy audit conclusions are based on calculation tool created by MOTIVA. The procedure contains the tables which must be filled. The report must follow the instructions and the form for energy audit.

Implementation of the proposed actions

The implementation phase includes the following steps:
1. Delivery of the report
2. The operational measures
3. Investments and other measures in the continue

The results of the audit report must be presented to the customer in a special event. The energy auditors examine all the topics dealing with energy economy with the managers and the personnel, such as possible changes in controls and in timing.

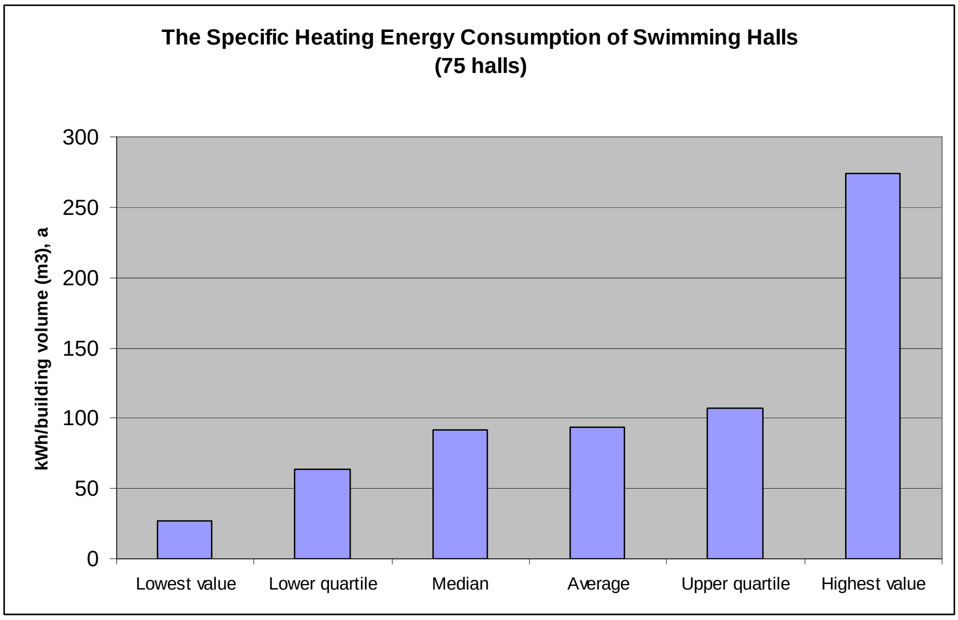

Figure 4. Statistical abstract of specific heating energy consumption of 75 swimming halls.

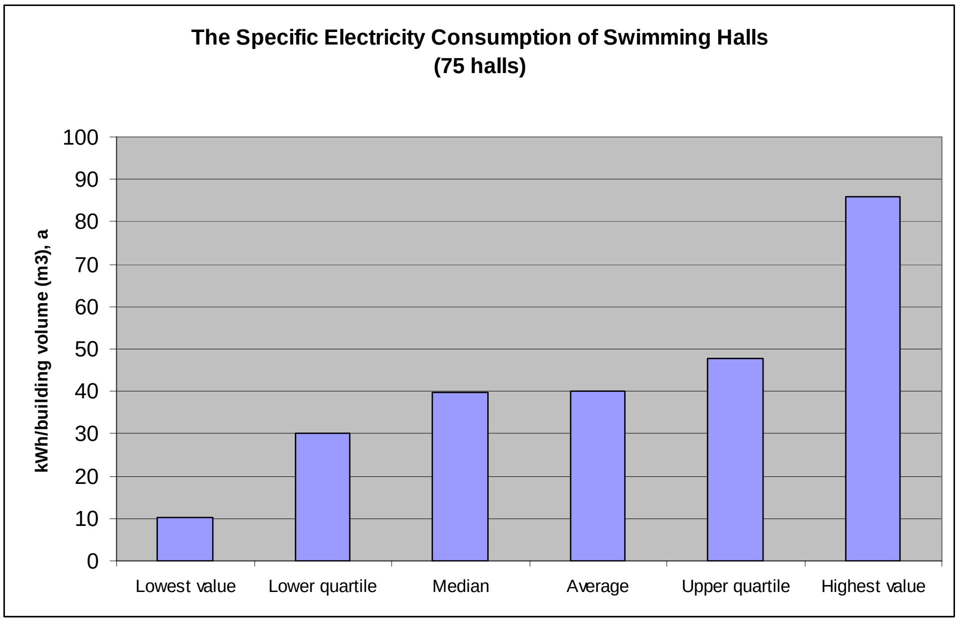

Figure 5. Statistical abstract of specific electricity consumption of 75 swimming halls.

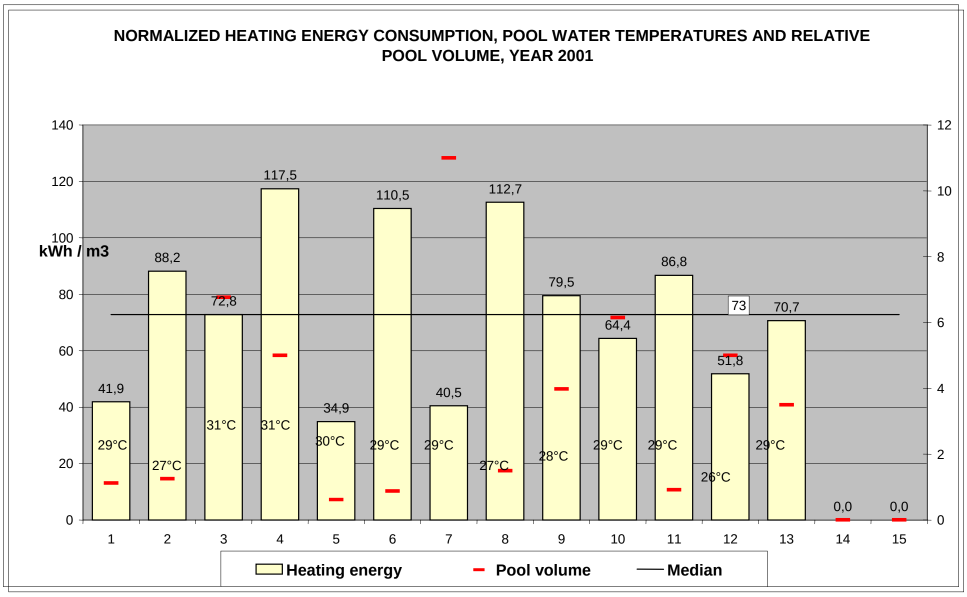

Figure 6. Heating energy consumption per building volume in 13 spa hotels /7/.

The yellow columns show the normalized heating energy consumption in thirteen spas in the year 2001. Combined with heating energy costs figure, one can easily make conclusions on each target - if the heating costs and also the energy consumption is clearly below the median (taking into account all the factors), there is probably no urgent problems. The median = black horizontal line in the figure.

Table 3. Saving potentials of some audited building types /8/.

Building type	Number of buildings audited	Heating			Electricity			Water		
		Cosumption	Savings potential		Cosumption	Savings potential		Cosumption	Savings potential	
		GWh	GWh	%	GWh	GWh	%	1000 m3	1000 m3	%
Office buildings	278	275	49	17,7	261	16	6,2	814	71	8,8
Sports buildings	60	55	11	20,1	35	3	7,5	435	23	5,2
Schools	460	295	41	14,0	62	5	8,2	751	80	10,6

URHO – MAINTENANCE RECORD BOOK SOFTWARE

Knowing the challenges to operate and maintain any specific and demanding building VTT has created maintenance software tool (URHO) that is specially designed for indoor swimming pools and spas (figure 7). URHO helps the maintenance staff to operate and maintain the facility systematically. The software enables staff to get detailed and real time information about following themes:

- What tasks should be done and when (service task calendar)?
- How should these tasks to be carried out (service instructions)?
- What kind of service operations have been done for this building part or building service system before (service history)?
- What tasks are not completed yet?

URHO is quick to use and easy to learn. URHO can be used in one single workstation or via intranet. Program updating and data-savings can also be done comfortably via internet. One of the main advantages of URHO is its flexibility. The user can choose many different ways to build up the files and the whole maintenance record system. Among others URHO is used by the personnel of the largest Finnish swimming halls, Mäkelänrinne in Helsinki and Raksila in Oulu.

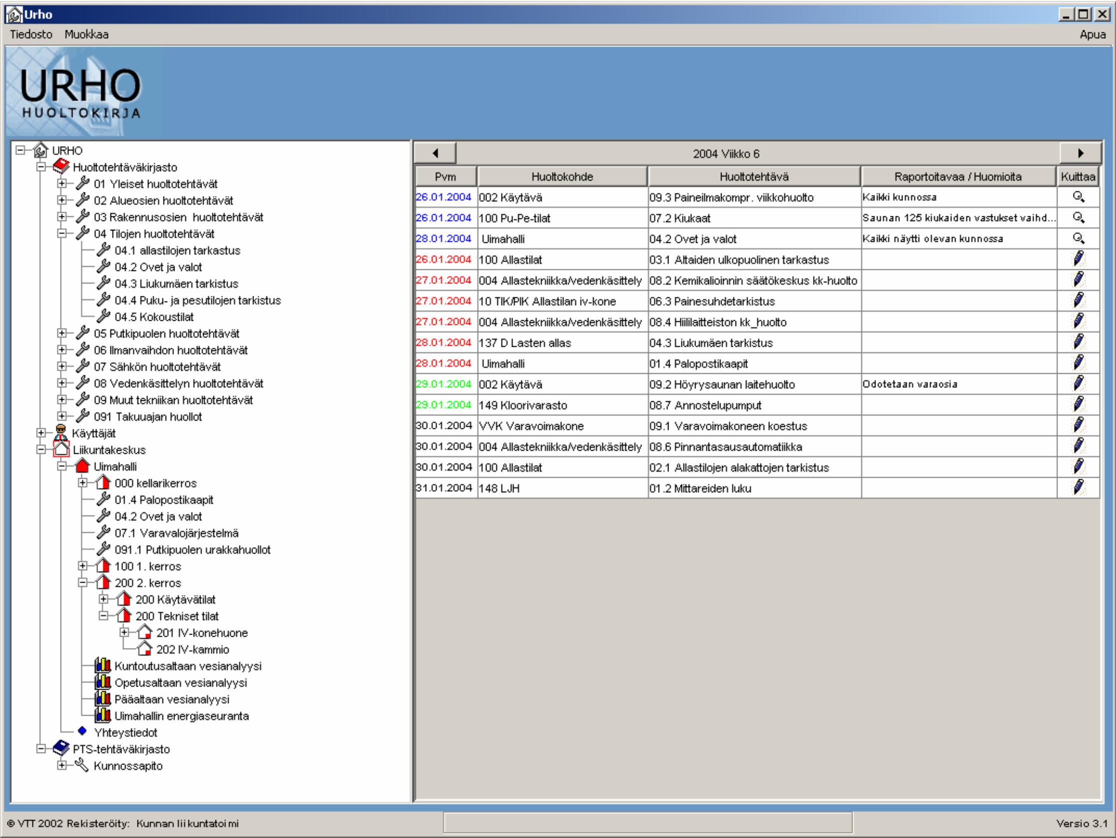

Figure 7. One outlook on URHO maintenance record book. Service task files and service targets on the left hand sight and service task calendar on the right hand side.

CONCLUSIONS

The swimming halls are one of the most used public buildings in Finland. The running costs of these facilities are high and there is a significant savings potential to be achieved. The systematic condition survey procedure helps in determining the actual needs of repairs and optimizing the life cycle costs. By monitoring and benchmarking we can find out the possible need for energy audits. Energy audit itself is relatively non-expensive action and it can be utilized effectively to save and optimize energy costs. It is also important to monitor systematically the consumptions and conditions. These can be done for instance by URHO on-line monitoring system. It is recommendable to use systematic maintenance record book as a tool in daily operations and maintenance tasks.

- It helps in short-term and long-term maintenance planning
- The repairs and renovation measures can be allocated and done in time
- The result is the optimal life-cycle, good condition and satisfied users.

REFERENCES

/1/ Lipas. Computer based information system of sports sites and facilities. Jyväskylän yliopisto. http://www.sport.jyu.fi/lipas
/2/ Nissinen Kari, Niskala Mikko, Päkkilä Kari. Liikuntarakennusten elinkaaren kustannukset. *(Life Cycle Cost of Sports Buildings)*. Opetusministeriön Liikuntapaikkajulkaisu 60. Rakennustieto Oy. Helsinki 1996. 149 pages. ISSN/ISBN: 1236-0694 / 951-682-419-6. Revised 2004 by Kari Nissinen.
/3/ Uimahallien korjaustutkimus. *(Study on Indoor Swimming Pool Renovation)*. Opetusministeriön Liikuntapaikkajulkaisu 68. Rakennustieto Oy. Helsinki 1998. 43 pages. ISSN/ISBN: 1236-0694 / 951-682-486-2. Authors: Nissinen Kari, Niskala Mikko, Jalas Johanna, Pernu Pentti.
/4/ Pietiläinen Jorma et.al. KULU statistics for swimming halls. VTT. Not published.
/5/ Väisänen, E., Möttönen, V,. Kauppinen, T. Facility management costs of spa and wellness hotels and rehabilitation centers. Published in ERES-2003 conference proceedings, Helsinki 2003
/6/ Energiakatselmuksen toteuttamisen ja raportoinnin yleiset ohjeet. *(The general instructions for the performance and reporting of energy audit).* Ministry of Trade and Industry, March 1998
/7/ Rantamäki, Pertti, Immonen, Kari, Merviö, Jukka. Uimahallien nykytilaselvitys *(The study on the present state of swimming halls)*. Opetusministeriön liikuntapaikkajulkaisu 54. Rakennustieto Oy. Helsinki 1995. 33 pages. ISSN/ISBN 1236-0694/051-682-384-X
/8/ Energiakatselmusten tuloksia. *(Results of energy audits).* Ministry of Trade and Industry, 2004.