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Investigation of the energy performance and renovation opportunities in a historic building

using questionaire and assessment scale for decision making

and

improving energy performance.

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Abstract

On a global scale it is estimated that the building sector accounts for about 35% of the final energy use. The building sector accounts for nearly 40% of energy demand in European union (EU) and in Sweden too it is almost the same percentage demand. It is also known that more than 40% of the residential buildings in Europé were built before 1960 when the energy performance regulations for buildings were not so strict in view of the climate change objectives.

Compared to other countries in the EU, Sweden has a large number of listed or historic buildings as almost 15% of multi-family buildings and 27% of all single-family houses in Sweden were built before 1945. However it also stated that research on listed buildings energy efficiency potential and indoor environment is very scarce in Sweden.

Due to climate change and the need to reduce greenhouse gas emission (mainly CO_2) associated with reduction in energy use in buildings is very evident. Some buildings are of heritage significance due to their historical, architectural or cultural values. The Swedish standard SS-EN 16883:2017 refers to them as listed or historic buildings. This standard does not presuppose that all historic buildings need energy performance improvements. The use of this standard is not limited to historic building with heritage values however it can also be applied to historic buildings of all ages and types.

This study presents an assessment of a historic building built around 1945 where both the building owners energy use data and the building tenants or users indoor environment perceptions includes their expectations on daylight needs, illumination, temperature control or heating and ventilation are evaluated by the assessment scale methodology recommended in the Swedish Standard SS-EN 16883:2017.

The results obtained have been presented on an assessment scale as per SS-EN 16883:2017 also considering the building users perceptions of the indoor work environment. This could be a basis for future decision making for the building owner considering the planned investments on prioritized and feasible energy effective measures. Thus this study is based on quantitative approach. This assessment scale decision making model can be a basis for future builing investigations and investments plans in building refurbishments leading to improvements in energy performance of this historic building.

Keywords:
english
Listed building, Energy performance, Energy efficient measures, historic buildings, Energy use, Indoor environment, Building survey and accessment, Energy efficient measures.

swedish
Byggnadsminne, Energiprestanda, förbättring av energiförbrukning, historiska byggnader, energianvändning, inomhusmiljö, byggundersökning och bedömning, energieffektiva åtgärder.

Nomenclature

BBR	Boverkets mandatory provisions and general recommendations.
AFS	Arbetsmiljöverkets författningssamling-Swedish authority for work environment: Work environment Laws and regulations.
PBA	Planning and Building Act(2010:900)
PBO	Planning and Building ordinance (2011:338)
EPBD	Energy performance of building.
SS-EN 16883: 2017	Swedish standard – Conservation of cultural heritage: Guidelines for improving the energy performance of historic buildings.
OVK	Obligatorisk ventilations kontroll-Regulations regarding performance inspections of ventilations systems are given in PBO, in the Boverkets mandatory provisions and general recommendations (2011:16) on performance inspections of ventilations systems and certification of expert performance inspectors.
LCC	Life cycle cost analysis.
SEA	Swedish energy agency – Energimyndigheten
EU	European union.
IVL	Swedish environmental research Institute.
BUP	present Building users: Barn- & ungdomspsykiatri mellanvård Sydost, Stockholms Läns Landsting.
GHG	Greenhouse gases.
SBS	Sick building syndrome

Symbols and abbreviations used in the report are defined here, e.g:

Symbol	Description	Unit
Atemp	energy performance for heating only	kWh/m^2 per year
°C	air temperature	degrees celcius
l/s	air flow rate	liter/second
CO_2	carbon dioxide content	carbon dioxide
lm	luminous flux	Lumen
dBA	decibel	Unit for sound measurements
%	percentage	percent
m^2	area	square meter
m^3	volume	cubic meter

Table of Contents

1. Introduction

1.1Background

On a global scale it is estimated that the building sector accounts for about 35% of the final energy use as stated in Buildings performance institute Europé.[1]. According to the Swedish Energy Agency overview of 2016 the building sector accounts for nearly 40% of energy demand in European union (EU) and it is almost the same percentage demand in Sweden[2]. It is also stated by ”Europes building under the microscope 2011” that more than 40% of the residential buildings in Europé were built before 1960 when the energy performance regulations for buildings were not so strict in view of the climate change objectives.[1]
As per SEA 2016 compared to other countries in the EU, Sweden has a large share of listed buildings compared to other countries in the EU as almost 15% of multi-family buildings and 27% of all single-family houses in Sweden were built before 1945. However it was also stated that research on listed buildings energy efficiency potential and indoor environment is very scarce in Sweden. [2]
Due to climate change and the need to reduce greenhouse gas emission (mainly CO_2) which is very evident as it is associated with energy use in buildings. It is known that listed buildings are of heritage significance due to their historical, architectural or cultural values. The Swedish standard SS-EN 16883:2017 refers to them as historic buildings. This standard does not assume that all historic buildings need energy performance improvements. The use of this standard is not just limited to historic building with heritage values however it also applies to historic buildings of all ages and types. [3]

Literature reviews related to listed or historic buildings were found in the database Scopus and also the questionaire for building users shown in Appendix B which is commonly used for office premises was obtained from the IVL rapport, B1604, 2004.[4]

This study presents an assessment of a historic building built earlier than 1945 where both the building owners inputs and the building tenants or users indoor environment self experiences and perceptions are obtained by questionaires and then an assessment of energy efficient measures for improving energy performance is carried out as per guidelines in the Swedish standard SS-EN 16883:2017.[3] particularly shown in Table 1 and 2 annexed in Appendix A.

1.2 Literature review

It was stated by J Laustsen et al. 2011 that buildings can cause a significant amount of greenhouse gas emissions, mainly CO2, and can alter our planet's climate during coming years. By renovating buildings considering green technologies to higher standards of efficiency it can be demonstrated that ambitious climate change mitigation actions and improvements in indoor climate or environment can be achieved hand in hand.[1] The European commission, 2020 climate and energy action has objective to reduce global warming by focussing on reduction of green house gases. The comission has also published a revised directive on energy performance of buildings which includes requirements for buildings being built or rebuit. This implies changes for listed or historic buildings as defines in SS-EN 16883-2017.[3] Thus managers or owners of listed buildings have to preserve the buildings heritage value while making an efficient use of energy and meet the basic requirements of indoor environment, its operational running costs and energy performance.[5]

It was stated by SEA, 2012 that many of the old buildings had lost part of their heritage values due to inappropriate refurbishment measures like window replacements and facade insulation.[6]. As per P Gluch, 2014 Life cycle cost (LCC) analysis has been recommended as a useful tool from an economic point of view during the renovation of buildings. LCC analysis could be used to find comparable costs for different investment alternatives in building stocks.[7]

According to National board of Housing, Sweden 2010 in terms of energy saving potential in Sweden it is vital to investigate historic building stock because of the fact that older buildings have in general lower thermal performance as compared to newer building stocks.[8] Ståhl et al. 2011 studied listed buildings existing knowledge regarding sustainable and careful renovations and energy efficiency.[9] Liu et al. 2014 studied energy saving potential and LCC of residential buildings including one listed building. [10]

Boström et al. 2014 studied the methods to evaluate the potential for and study the consequences of energy retrofits in swedish historic buildings. [11] Other studies in this field include Judson et al. 2014 studied how listed building owners need to balance emerging needs for environmental sustainability at the same time retaining heritage values using qualitative interviews.[12] Moran et al. 2014 studied the use of passive house planning package a simulation tool to reduce energy use and CO_2 emissions in historic buildings.[13]
The overall conclusion is that the listed or historic building requires an individual approach as they have a heterogenous character due to construction peculiarities, location, applicable laws and heritage values. And there is no single universal solution to make historic buildings energy efficient and preserve their cultural values the guidelines from SS-EN 16883:2917 is utilized in this study.

Another perspective which has been considered in this study is the balance between energy conservation and building conservation. Kohler et al. 2012 stated that it is challenging to improve both the listed buildings energy performance and also to preserve its heritage value. [14]

As stated in the Swedish standard SS-EN 16883:2017 the energy performance is a measurable result related to energy use and energy use is the manner or kind of application of energy. Here the technical building system consists of technical equipment for heating, cooling, ventilation, humidity control, hot water, lighting or could be a combination of some of them. This standard as shown in Appendix C describes a procedure of selecting appropriate measures to improve the energy performance for a historic building.[3]

1.3Aims

The aim of this study is conduct an investigation of the energy performance and renovation opportunities in a historic building.

The specific objectives were:

- To collect available building data from the building owner as indicated in Appendix A as per guidelines in the Swedish standard SS-EN 16883: 2017 for historical buildings.

- To conduct survey by questionaire method as per Annexure B with focus on indoor environment and obtain useful inputs from the present building tenants or users.
- To use the assessment scale as per SS-EN 16883: 2017 and formulate basis for the management decision making by considering inputs from the building owners and building users. In addition consider the minimum requirements of applicable rules and regulations like Boverket(BBR 25), Arbetsmiljöverket (AFS 2009:2) as the building is presently being used as office premises. This shall act as a preliminary decision making method for prioritization of the most appropriate energy efficient measures to be implemented in near future considering the strategic goals of the building owner.

2. Theory

The energy performance of historical buildings is attracting growing interest in research and in practice.

Among the building stock in Sweden these are a large number of listed or historic buildings as 15% of all apartments and 27% of all single-family houses were built before 1945[2]. As shown by literature reviews, increasing numbers of articles on energy efficiency measures for historical buildings are being published in peer-reviewed journals. However, there is scarce research on how historical buildings energy performance is dependent on indoor work environment, regulations, considering expectations, behaviors and perceptions of the building users.

To address this gap this study was conducted by using the guidelines as per Swedish Standard SS EN 16883:2017 to decide on energy efficient measures for Conservation of historical buildings and to facilitate improvements in indoor work environment for the building users.

SS-EN 16883:2017 focusses on sustainable management of buildings considering the different aspects of energy performance, conservation and the feedback from the present building users.[3]

In the Swedish standard SS-EN 16883:2017 it has been mentioned that sustainability has four aspects:

- Environmental sustainability: In historic buildings care need to be taken to evaluate the use of materials and energy during the buildings life cycle including its construction, operation, maintenace, refurbishment and demolition and as far as possible renewable energy resources need be utilised to reduce emissions of greenhousegases.
- Economic sustainability: The building owners should consider all economic factors like its present market value, revenues from rents and operating costs and evaluate renovation measures enabling its long term use for other planned future use of the building.

- Social sustainability: Historic buildings also contribute being socially relevant for its present tenants and users and also has an asthetic and social footprint or importance in the nearby surrpounding locations.
- Cultural sustainability: Such a building need to be managed in such a manner that its heritage value is retained for its present and future usage.

As the standard aims to assist the historic building owners in applying the standard for energy efficiency measures in the long run.

It presents a systematic management decision making approach to arrive at the most suitable energy efficient measure based on the available data on the above four aspects in this case study.

It is also important to note that this standard states that all historic buildings need not have energy performance improvements considering its individual characteristics.

Some of the terms and definitions in the standard (SS-EN 16883:2017) are quoted below for easy reference

*”Building”*construction as a whole, including its building envelope and all technical building systems, for which energy is used to condition the indoor climate, to provide domestic hot water and illumination and other services related to the use of the building.

”Environment” natural, man-made or induced exernal or internal conditions that can influence performance and use of the whole or part of a building.

”historic building” building of heritage significance.

”technical building system” technical equipment for heating, cooling, ventilation, humidity control, hot water, lighting or for a combination there of.

”Investigation” gathering of all information necessary for a conservation decision making process.

”Energy-capacity” of a system to produce external activity or to perform work.

energy performance improvement measure-action to achieve behavioral, design, economic or technical change leading to verifiable, measurable or estimable energy performance improvements.

”energy perfomance” measurable results related to energy use and energy consumption.

”Principles of building conservation”The principles of conservation shall be considered when we plan and implement energy performance improvements in historic buildings. All measures shall be in accordance with the building conservation principles given in standards, guidelines and charters.
It is to be noted that maintenace is the best conservation measure. Thús any improvement measure should facilitate continuous preventive maintenace of the building.

Description of the study object
The building was in use during 1945 as Figure 1 as shown in this engraved stone.

Figure 1: Building name inscribed during 1945

The building Bysten 1 analyzed in this study is located in Stockholm (Sweden), more precisely, in a neighborhood called Johanneslov, located very close to Globen in Stockholm city.

The studied building was build prior to 1945. As it was stated that during 1945 the building was initially used by jewish pensioners who came to Sweden after the second world war. This is a two storeyed building with a basement and is located at Skulptörvägen 8, 121 43 Johanneshov in Stockholm.

3. Method

3.1Materials

On site measurements were carried out with Instruments obtained on loan from the Gävle university college as shown Figure 2.

- Air flow meter - Swema Twin.
- CO_2 detector - Rotronic CL 11
- Air velocity meter – TSI VelociCalc Plus model 8360

Figure 2 Measuring instruments used

Since during the study updated building drawings were not available some measurements of air flows in offices were conducted to reconfirm the feedback from the building users.

For the sound and illumination measurements, a mobile app by Arbetsmiljöverket has been used.

Indoor workenvironment survey was conducted using questionaire applicable for office premises as shown in Appendix B.[4]

In addition to survey by questionaire method complementary interviews were conducted telephonically with Triennium Fastighetsentreprenad AB.

Building information or data

Table 1: Information of building under study

Property name	Bysten 1
Adress	Skulptörvägen 8, Stockholm
Muncipality	Stockhölms stad
Frehold/leasehold area	Freehold
Area building m^2	1055
Surrounding open area land m^2	890
Tenant/building user	Stockholms Läns Landsting
Construction year	Around 1945
Fasad	Brick tile
Construction	Concrete
Foundation	Concrete sole
Windows	Double glazing
Roof felting	Concrete roof tiles
Ventilation	FTX
Water & Sewage	Muncipality system
Heating	Oil fired boiler
Ventilation permit	OVK without remarks
Lift	Available in the building

The real estate company Ledstången AB ownes Bysten 1. It has other companies in their group like Svenska Samhällsfastigheter AB and Carlek fastigheter.

Since 2005 the building is rented out to Stockholms läns Landsting. BUP has about 20 staff members. Their patients or clients are childrens in the age group of 6 to 16 years with need of psychiatric care. The building has offices for staff and group rooms for counselling with individuell clients or childrens alongwith their parents.

In the basement the staff have a gym for training and presently the attic area or roof floor is utilised for storage and ventilation system is installed in this area.

Building user is department: BUP Mellanvård Sydost. Avdelning för närsjukvård Stockholm.

The studied object has an area of approx 1055 m^2 and outside open area of approx 890 m^2 is shown in Figure 3.

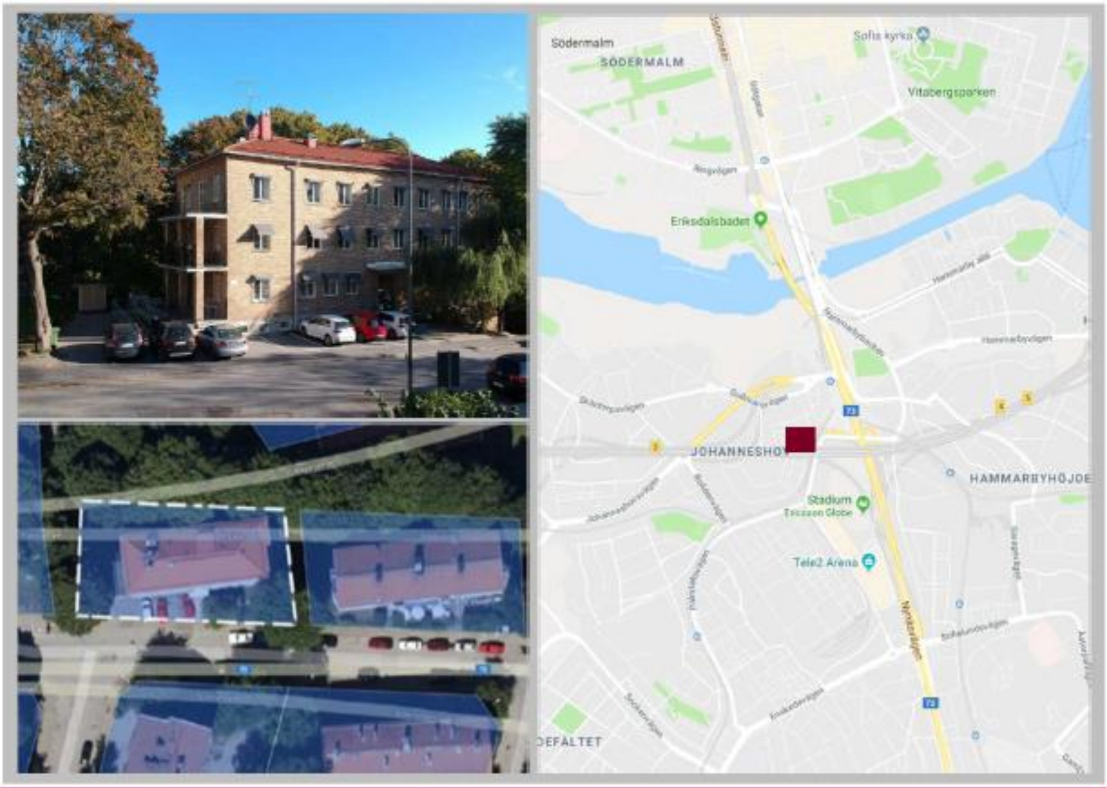


Figure 3: Building location in Stockholm

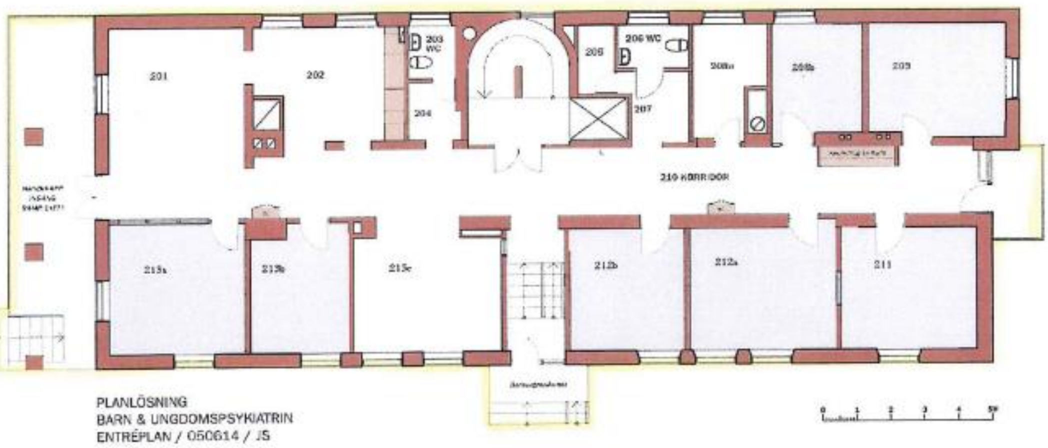
The building has a oil fired boiler for heating system. The energy declaration was submitted during 2012 and some measures for reduction in energy use was recommended like explore use of district heating system however it was not studied or implemented at the time of the study.

The present ventilation system with heat recovery (MVHR-FTX) has been in use since 2000. And the oil fired boiler was installed during 1987 (over 32 years). The hot water storage tanks were manufactured during 1945. All pipe linkages for hot water distribution were almost from early 1945.

The building owners could share information on last energy declarations reports. Last three years trend on energy use and also annual consumption of oil for oil fired boiler and water consumptions for the building was obtained during the study.

The general layout of the building is shown in Figure 4

PLANLÖSNING
BARN & UNGDOMSPSYKIATRIN
KÄLLARPLAN / 050614 / JS



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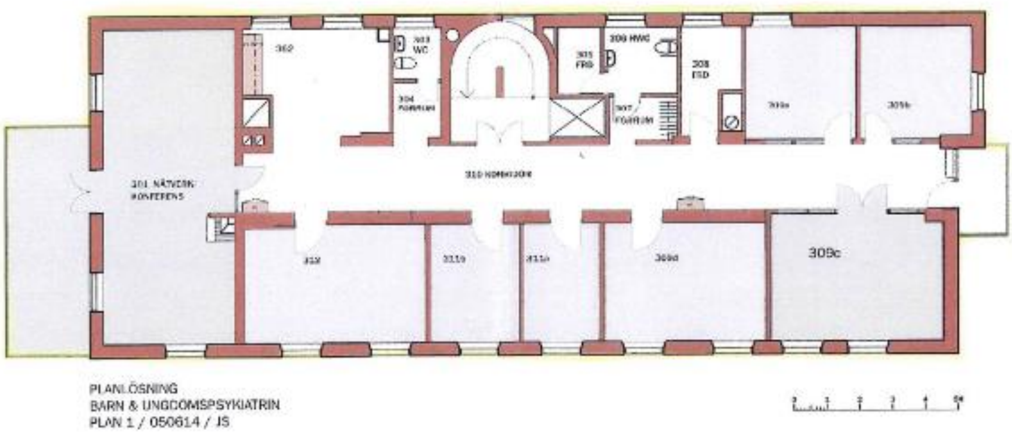

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PLAN 1 / 050614 / JS

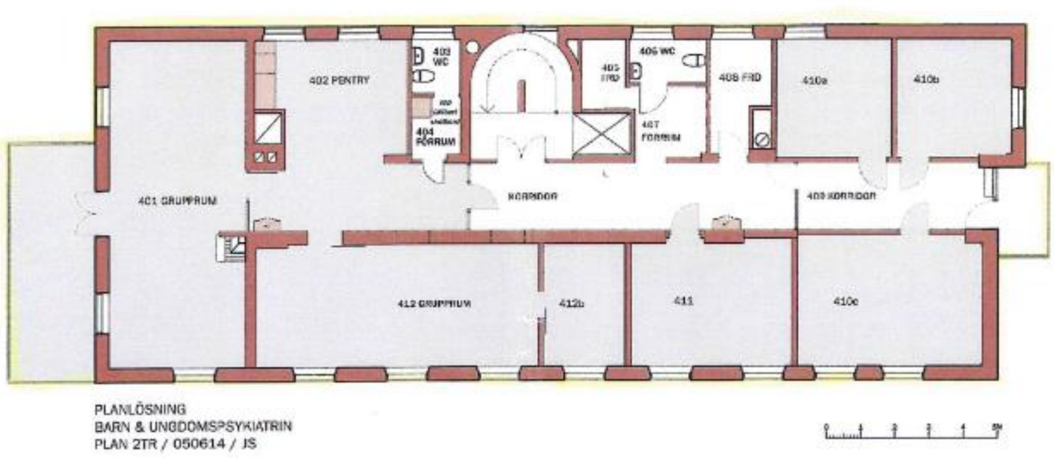


Figure 4: Building layout: Basement, entrance floor, floor 1 and floor 2

3.2 Procedure

The building owners Ledstången Stockholm AB was sent request to fill in available building information or data as per Annexure A. During visits and mail contacts the energy use data and available information was colected.

As the building owner had secured the property for two years ago. In this study this is also a factor to be noted when historical buildings have several different owners under their life time. Also lack of updated drawings, inadequate information from building maintenance system and also lack of time to verify the building technical data has compelled the researcher to make certain assumptions which is stated during evaluation.

On receiving the inputs attempt has been made to compare and evaluate the risk assessment to identify the best energy efficient measures and propose elimination of inappropriate ones during the later implementation phase.

This methodology is also in line with the recommedations of the Swedish work environment authority rules on work environment systems 2001:1 where it is always recommended that employers regularly conduct assessments and surveys by discussions or questionnaire and seek feedback from the staff working in the building premises and evaluate the risks perceived by users and then evaluate the measures for improvements by dialogue and negotiations with the building owners considering the present building users needs, the available technology and organizational capability considerations the minimum requirements for health, safety and indoor workenvironment applicable for the present building use i.ex as office premises.

As mentioned in SS-EN 16883:2017 as building users behavior is known to influence in efficient energy use and result in significant energy savings without even investing in significant retrofits or alterations in the building. A seperate survey questionaire as shown in Annexure B which was obtained from IVL report 1604, 2004 was sent by Google docs email in Swedish language for the inputs from the building users.

The intention of the study is to use both the shareholders i.e. the present building owners and building users inputs and assess the energy performance measures to achieve the building owners energy and climate goals and also improve the indoor workenvironment for the building users.

A combination of methods has been used in this study, including a survey on indoor environment by questionaire, feedback from the building owners regarding energy use and on-site measurements of air flows, heating, CO_2 and illumination.

The methodology used in this study is illustrated in Figure 5.

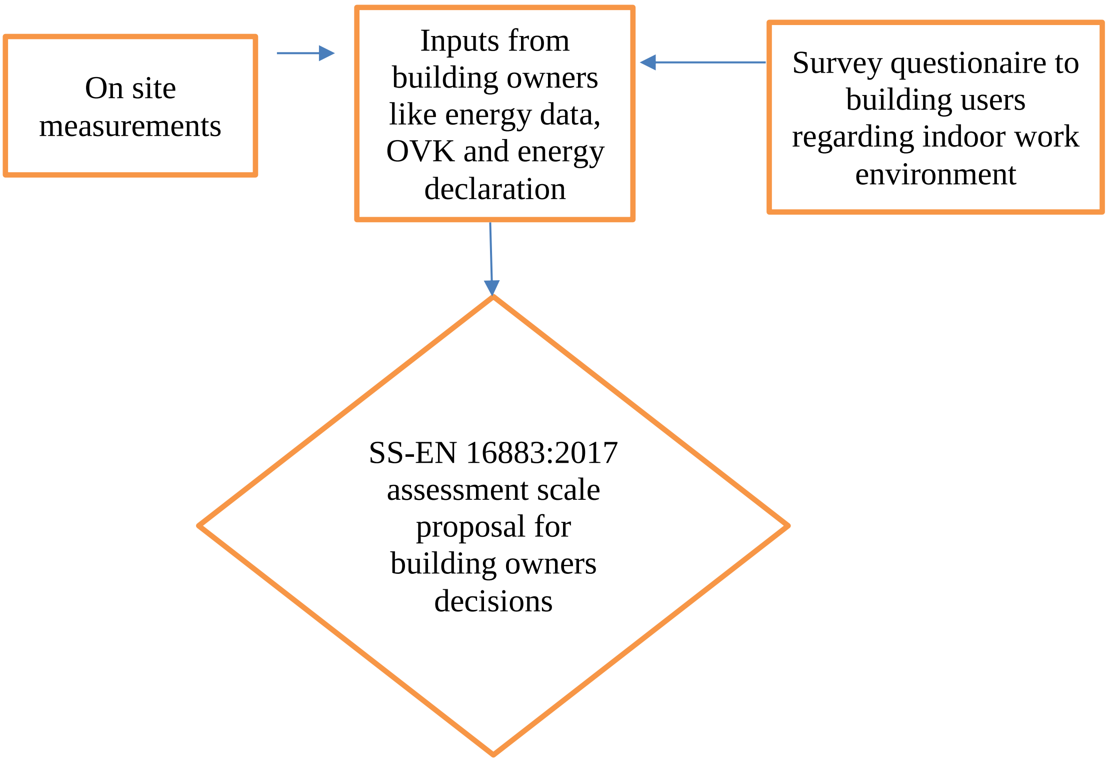


Figure 5 : Methodology approach used in this study

The survey on indoor environment was conducted by sending questionaires to the building users and also three physical visits were made to the building site to conduct measurements and telephonic interviews with building maintenance staff.

Due to convenience of participants Interviews with building maintenace staff and oil supplying company was conducted by telephone.

The building owners has a vision to achieve sustainability goals with a management decision processes considering the environmetal, economic, social and cultural aspects to maintain the building stock for the present and future use.

It is typical for historic or listed buildings to change owners and be used for different end use. A company from Gävle named Triennium Fastighetsentreprenad AB (www.triennium.se) has recently secured contract for maintenace and caretaking of the property as it acquired the earlier caretaking company named Adriana AB. So it was good opportunity to study this object with changed owners and new staff for maintenace and caretaking.

4 Results and analysis

Energy use

Electricity distributor	Ellevio
Agreement	With Mälar Energi
Customer name	Svenska Samhällsfastigheter Bysten AB
Customer no	4055422
Actual consumption during 2017 upto may 2018	30 190 kWh
Total extimate during 2019	27 371 kWh
Last electricity measurement done	2019-05-01
Type of measurement	Monthly
Meter type	C1
Energy meter number	7613207912945192
Meter installed date	2009-02-09
Constant	1
Active network contract	Simple
Contract valid from	2015-11-01

Electricity consumption data from 2018-2019 is shown in Figure 6

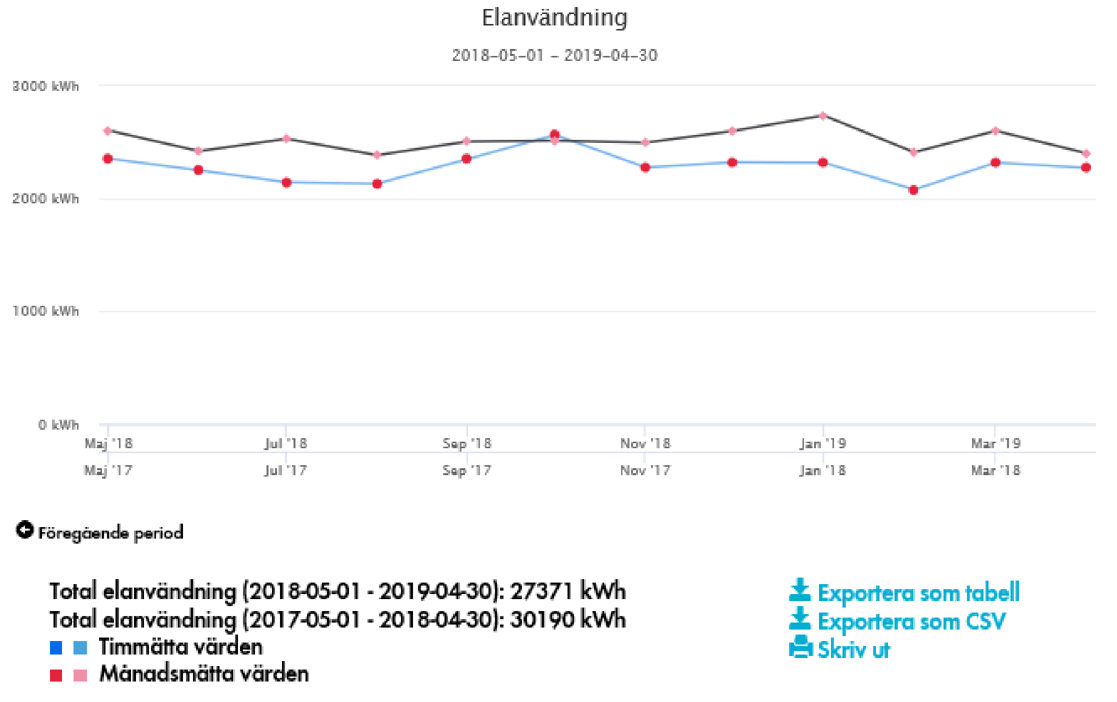


Figure 6 Energy use during 2017-19

Electricity use during 2015-2019 is shown in Figure 7.

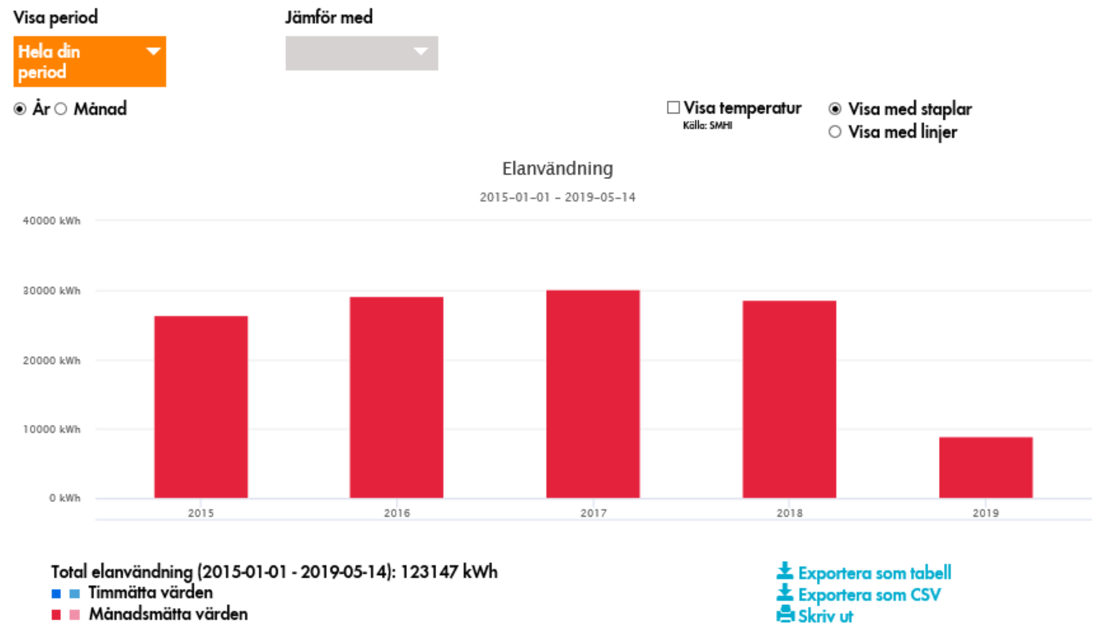


Figure 7 Energy use 2017-19

Electronic equipments utilised in the buildings were
Televisions, digital video players, desktoptop computers, halogen lamps and about 35 tube lights. Energy use : 30 190 kWh per year (during 2017-18)
In this study we assumed that about 30% energy use was for office consumption. These assumptions can be done as per Energu audits of Buildings, SIS publcation 2007(20).

Quality control or verification of the Building owners information or data on rents/maintenace expenditures could not be done during the study.

Studied energy declaration from 2012 as shown in Appendix D and the energy use data from 2015-2019 from Ellevios meter readings revealed that the building has a energy demand of 293 kWh/m^2 and year of which the electricity demand was about 17 kWh/ m^2 and year (annual consumption then was approximately 21.823 kWh/m^2). The present electricity consumptions reveal that electricity use has increased. Possible reasons could be due to replacement of fans or increase in the use of office equipments or due to leakages and transmission losses in the building envelope. It needs careful detailed study and analysis of leakages in the windows, open doors, attic floor with broken windows etc need to be maintained as corrective measures.

Building has only one energy meter which registers total energy use for the building including heating, hotwater, building and office electricity usage. Present electricity contract per phase and fuse type is 3x25A. The present last three years energy use is varying between 25.500 kWh to 30.000 kWh per year. The building owners need to investigare it further by initiating closer controls.

Ventilation system information

- Mandatory Ventilation control certificate as shown in Apendix E was conducted during 2017 and without any remarks. Report was considered OK by the certified person as there was no remarks or suggestions for improvements.
- Ventilation system: Installation year 2000, Product type: ESC-18-00-N1-LS/FTX. Product name: IV product, Type name: LA1, filter klass: F7 and final pressure drop 200 Pa.
- Heat pump and heat exchangers manufacturing year: 2000.

- fans and air flows at the ventilation unit was without any deviation remarks from the certifying person in OVK shown in Appendix E.
- Operating hours for ventilation system: 07:00 to 18:00hrs
- Last change in air flows done: data was not available at the time of study.
- Measured air flows in pantry areas on the entrefloor and first floor showed results which were borderline cases in line with the feedback from the building users who experienceced insufficient air flows and heating: Just half of the designed values in offices and pantry area i.e about 9 l/s. And it was satisfactory as per designed values in toilets approx 20 l/s. Often inadequate heating is the main cause for compliants in indoor work environment in office room, pantry and group rooms in the building which in turn has to also comply with air flows like 7 l/person och second plus 0.35 l/ m^2 floor area requirements by AFS 2009:2 needed for office premises.

CO_2 measurements in single user offce was approximately between 400 to 650 ppm. Minimum requirements is to maintain it below 1000 ppm. It could be stated that further measurements need be dome in group rooms during counselling with patients to see whenther the limits are exceeded. Else suitable ventilation solutions need be investigated.

Illumination in the corridor were between 350-450 lumen and in offices facing towards road there was enough day light available. Sound levels in corridor and office was between 40 to 50 dBA.

Indoor temperature: between 21-22 °C.

Oil fired boiler

- Oil fired boiler: manufacturing year 1945.
- Boiler efficiency: 75%
- Effect : 90 kW.
- Installation/location: In basement
- Other observations: present regulation valves manual. Could be replace by auto valves.
- Use of oil: approx 19.384 m^3/year, consumption data was taken directly from the oil distributor.

Looking at the below consumption we could see that the boiler had almost consumer about 12.389 m^3 uptill may 2019.

2018	2019
27 jan 3,875 m^3	21 jan, 3,752 m^3
28 feb 3,253 m^3	17 feb, 2,712 m^3
29 mar, 3,286 m^3	19 feb, 1,553 m^3
8 maj, 2,207 m^3	14 mar, 1,952 m^3
30 aug, 0,06 m^3	17 apr, 2,42 m^3
7 nov, 2,46 m^3	
14 dec, 1,06 m^3	
27 dec, 3,76 m^3	

CO_2 emisisons only with the oil consumption data for 2018 is approx

= 19.384 x 2,68 ton CO_2/m^3 = 51.94912 ton CO_2/m^3

[Oil used is E01 E10 max, 0.05 % S (coloured)]

So need is to explore potential for electric heating or district heating and replace the oil fired boiler.

- Any feedback from building care taker on the faults/repairs undertaken during last five years were unavailable during the study.

Other electricity needs, If electricity was used for heating car engines: no

Environmental factors

- Renovations with damaged Buidling materials containing asbest etc: unavailable during the study.
- Radon measurements: unavailable.

Other information

- Lift available
- Water and sewage: Stockholms städ, muncipality system

Water consumption

Floorheating and roof heating not available. Installed water meter since 2012. Average water consumtion approx 576 m^3. In this study we assumed that hot water consumption was about 20% of the total water consumtion based on Åsa W et al. 2007[20].Use of hot water is generally low in offices as few take shower in such facilities compared with school buildings.

Solar heating: not utilised.
Data on use of renewable energy sources: not installed or used.

Feedback from the building owners

As per table 1 of SS-EN 16883:2017 - Annexure A — assessment categories and criteria of possible measures the following inputs were obtained from the building owners

Table 2 Building owners feedback based on SS-EN 16883:2017

Assessment category	**Assessment criteria**	**feedback**	**Suggested performance improvement measures**
Technical compatibility	hygrothermal risks	Unavailble at the time of the study.	Monitoring of the ventilation system and replacement of the oil fired boiler. Reduce windows transmission leakages, study need based ventilation system and initiate a subsequent building survey and assessment

			for detailed plan approvals.
	structural risks	Same as above	
	corrosion risks	Same as above	
	salt reaction risks	Same as above	
	biological risks	Same as above	
Heritage significance of the building and its settings	risk of material, constructional, structural impact	Present building owner confirmed building as a listed or historic building.	
	risk of architectural, aesthetic, visual impact	Same as above	
	risk of spatial impact	Same as above	
Economic viability	capital costs	Likely Investment based on LCC.	Needs a subsequent detailed discussion on existing rent contract and refurbishments costs and increase in building rents etc.
	operating costs, including maintenance costs	Figures from 2015-16 indicated that amount was variable between SEK 300,000 to 350,000. New contract since	Review costs during 2019-20

		nov 2018 so needs further analysis and review.	
	economic return	Earlier annual rents approx SEK 2,000,000	
	economic savings	Marginally low considering frequent maintenance and repairs carried out.	
Energy	energy performance and operational energy demand in terms of: — primary energy rating (total) — primary energy rating (non-renewable) — primary energy rating (renewable)	approx between 27.500 to 30.500 kWh per year. agreement with MälarEnergi, Västerås. Not considered	Explore district heating system or change to electric heating as Oil fired boiler manufacturer does not offer reserve for repairs as unit is over 30 years old. Considering CO_2 emisisons oil fired boiler should be discontinued during 2019-20.

	Life cycle energy demand in terms of use of renewable primary energy and nonrenewable primary energy	Unavailble at the time of study.	Needs further building survey and assessment.
Indoor environmental quality	indoor environmental conditions suitable for building content preservation	Unavailble at the time of study.	Ventilation system needs overhaul and also adjustments of air flows need be done so that building users always get the minimum recommended air flows as per Swedish work environment applicable rules. AFS 2009:2. Target objective should be to ensure saisfaction with indoor environment.
	indoor environmental conditions suitable for building fabric preservation	Unavailable at the time of the study	

	Indoor environmental conditions suitable for achieving good occupant comfort levels	OVK report conducted during 2012 was available for study.	Functional test of the ventilation system recommended. Maintenace instructions need to be reviewed, updated and implemented with new building maintenace personnel.
	emission of other harmful substances	No comments or remarks in OVK.	Measurements of air quality recommended based on building users inputs.
Impact on the outdoor environment	greenhouse gas emissions from measures implemented and operation	Evaluated only the oil consumed by the oil fired boiler. In similiar way other activities like use of vehicles, office equipments or operating times etc can be studied.	Consumption of oil for heating is to be discontinued due to Boverkets BBR 25 and Naturvårdsverkets new requirements. It is also desirable to meet national energy and climage goals.

	natural resources use	Day light adequate.	Need to review day light conditions in the gymnasium in the basement.
Aspects of use	influence on the use and the users of the building	Presently used as office premises. few building users have been at the same workplace since 2005, so we had good opportunity to seek their perceptions of indoor environment in the questionaire survey.	Building users need to be involved in effective use of energy and control of ventilation, illumination and heating system could optimise energy use & controls.
	consequences of change of use	Not available at the time of study. Building could be suitable as school or old age homes in future considering applicable rules and regulations.	
	consequences of adding new technical room	Not available at the time of study	
	ability of building users to manage and operate control systems	agreement with Triennium Fastighetsantreprenad AB a Gävle based company having	Could be beneficial to carry out joint visits and share results with the building

		office in Stockholm. Presently they have telephone helpline services where the personnel decide to send maintenace staff to visit building on as required basis.	users to raise their conficence levels and find suitable knowledge sharing meetings with building users.

During telephonic interview it was evident that building maintenace personnel desired more information or training requirement on maintanence of Ventilation system and heating system. They received more compliants about air flow and heatings from the building users. It was a challenge for maintenace staff as all documentation was not available and major repairs statistic was not updated.

Also need was felt for updated operations and maintanence instructions from manufacturers of oil fired boiler and ventilation systems. This is crucial aspect when companies get acquired by other companies that the company management has to make necessary investments in training of their staff and also use maintenace programs to analyse frequent failures etc so that the building users needs and requirements of indoor work environment are fulfilled in addition to the end objective of effective use of energy.

In this study the questionaire called Örebro enkäten as shown in Annexure B is used as a relevant questionaire for investigation of user opinion about perceived indoor work environment.

In this questionaire the question about respondents sex was deleted as it was known that mostly woman employees are working in this building. As we wanted to know respondents opinion in prioritising investments in the work environment. The last question was added from user perspective on which option should the building owner consider in energy retrofit from the indoor work environment perspective.

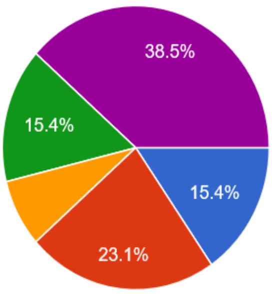
It was clarified to the respondents that the objective of the questionaire was to collect information, analyze and prioritize energy saving measures for this building which happens to be their workplace.

The respondents received the questionaire in Swedish language. It was assured that no personal information would be saved or reported in the study.

As the survey was voluntary and we could receive anonymous response in Google forms. As the building users comprise of 20 staff. Considering the population size of 20 respondents about 10 days was available to respond to the questionaire.
In this study we have 13 responses from among 20 staff, which is about 66 percent response.

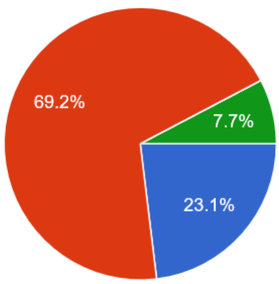
Results and feedback from the questionnaire to the building users is illustrated below

- It was seen that 5 respondents that was almost 38.5 % had worked in the building more than 10 years.



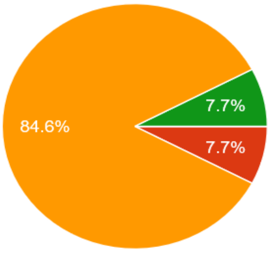
	respondents
o 12 months	2
1 to 3 years	3
4 to 5 years	1
6 to 10 years	2
more than 10 years	5

- From the year of birth inputs we could get feedback that respondents had age group between 29 to 60 years.
- Here we could see that almost 9 out of 13 respondents that is almost 69.2% worked in office room shared with other collegues.



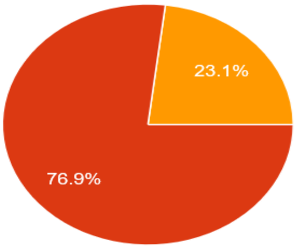
	respondents
seperate office room	3
share office room with another colegue	9
open office space	
other not mentioned above	1

- 11 out of 13 respondents worked on the first floor. That is almost 84.6 % of the respondents stated that they worked on the first floor.



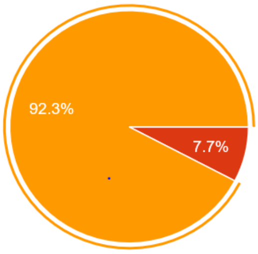
	respondents	
Basement		
entre floor	1	
first floor .	11	
second floor	1	
Attic or top floor		

- 10 respondents that is 76.9 % repondents stated that their office was not painted or renovated during the last five years. 3 respondents stated they didnt knew about it.



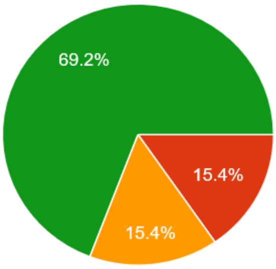
	respondents
Yes	
No	10
Dont know	3

- Almost 9 respondents of 13 stated that they did not have any water leakages or moisture ingression in the rooms and 4 respondents stated that they were not aware of it.
- Almost 11 respondents stated that did not have any any asthma disorders or were affected by ecksem. However 10 respondents stated that they knew some other colleguaes who had cold or other disorders in the building.
- 5 respondents stated that they felt tiredness often in the building and 7 stated that they felt tired sometimes. Only one respondent had headache problem. So building related sickness is not so evident. 11 respondents stated that they had headache sometimes. Other symptoms were not so significant in the building during the last three months.
- 11 respondents stated heating was unacceptable or bad and 2 respondents stated it as very bad during winter and autumn season. Most felt that the heating was acceptable during summer and spring.
- 12 respondents stated that they could not influence or control heating at their workplace. Only one respondent stated it had reasonable control.



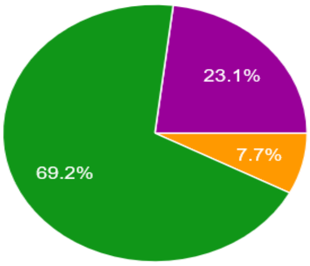
		respondents
●	Yes I can influence	
●	reasonable control exists	1
●	No options to influence	12

- 9 out of 13 respondents that is almost 69.2% did not experience draught in the workplace. Only two respondents felt little draught.



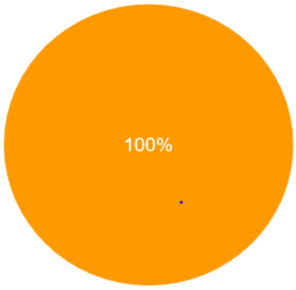
		respondents
●	Very much	
●	Little	2
●	Dont know	2
●	Not at all	9

- Only two respondents felt draught at windows or at the door.
- 9 out of 13 respondents perceived air quality was unacceptable or bad. 3 respondents felt it was very bad. One respondent perceived it as acceptable.



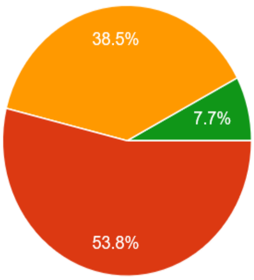
		respondents
●	Very good	
●	Good	
●	acceptable	1
●	bad	9
●	very bad	3

- 12 out of 13 repondents never felt or smelled any undesirable odour at the work place. Only one repondent sometimes felt undesirable odour in the building.
- All 13 repondents stated that had no options to influence or control the air flows or ventilation in the building.



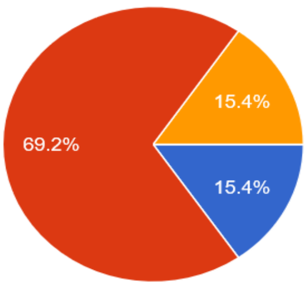
	respondents
Yes I can	
reasonable control exists	
no options to influence	13

- Almost 10 of 13 respondents did not have any problems with undesirable sound or noise from vehicles on the road or ventilation or washing machine or drainpipes etc in the building.
- 7 repondents felt the workplace was quiet. 5 respondents were unsure and would need a monitored report for verification. Only one respondent felt presence of noice at the workplace.



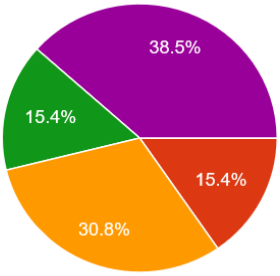
	respondents
Very quiet	
quiet	7
dont know, would like to know the measured results	5
significant sound levels	
High sound levels	1

- 9 out of 13 repondents felt the dayllight availability or illumination was good. Only 2 respondents felt it was dark at their workplace.



	respondents
Very good	2
Good	9
dark	2
Very dark	

- Only 4 respondents of 13 rated indoor workenvironment as acceptable. 5 respondents were not satisfied with their indoor workenvironment. 2 respondents were neither satisfied or dissatisfied or satisfied with the indoor work environment. This is high risk factor and so the building owner need to identify the key influencing factors like ventilation and heating system while considering the prioritization of energy efficiecny measures according to assessment scale towards measures to improve the indoor work environment and aim at building users satisfaction.



	respondents
very satisfied	
Satisfied	2
acceptable	4
neither satisfied or dissatified	2
not satisfied	5
very dissatisfied	

- The last question was specifically added for this study and the researcher asked the respondents if they had any suggestions for improving energy perfomance of this building. The respondents could suggest more than one energy efficieny measures

5 respondents felt need for effective energy utilization, 10 respondents felt need to initiate measures to reduce pollution and assist mitigate climate change. 8 respondents felt the need to preserve the buildings historical value, about 9 respondents wanted electricity use from renewable energy soorces.
However all respondents have chosen more than one alternatives. This is a positive feedback that even the building users given a chance would use mutiple strategies to contribute towards ideas for improving energy performance of buildings.
User control of ventilation and healting and proactive maintenance of the buildings work environment control devices could achive these goals which indirectly will help the building owner improve energy performance and reduce green house emissions.

So we could realise that awareness of the repondents needs and applicable legal requirements and building users feedback for improvements will help in considering the suitability of the ventilation and heating system for the workplace.

5 Disscussion

The study started with on site measurements to verify some of the technical information about the performance of the building.
The mesurements included

- The indoor temperature.
- Air flow measurements at some places like office room, pantry areas etc.
- CO_2 measurements in office room.
- Analyse the electricity use of the buildings.

A combination of methods has been used in this study, including a standardized indoor environment questionaire, building owners questionaire based on SS-EN 16883:2017, and on site measurements of indoor environment to assess the internal building environmental conditions that can influence energy performance.

In this study the main approach of data analysis was quantitative. The process of data analysis in this study had two broader pespectives: measured environmental parameters, building owners data as well as building users surveys and researcher observations.

The questionaire was sent by Google docs to the 20 building users. This method will help us investigare how the building users experience the indoor environment.

According to the results and the available building energy consumption data the SS-EN 16883 assessment criterias and scale will be used to evaluate a list of possible measures as a starting point without regard to specific technical properties of heritage significance of the building.
Later the combined measures could be evaluated to achieve the energy and climate goals also considering the minimum requirements of applicable rules and regulations.

The areas where targets could be specified are

- Technical compatibility with existing structural, constructional and technical systems.
- Heritage significance value.
- Energy performance and sustainability aspects.

- Indoor environmental quality
- Impact on outer environment.
- Economic viability of refurbishmnet or retrofit and
- User comfort.

In the studies conducted by Tor Broström et al. 2018 regarding standardizing the indoor climate in historic buildings opportunities, challenges and ways forward the authors described how use of standards and risk management guidelines had focussed more on the decision process rather than outcomes which has been the objective of the conventional approach in the management of historical buildings. It was also mentioned that the by interviewing the building owners and maintenance personnel and integrating the assessment with these organisational objectives could lead to effective building energy management plans as it leads to a wider set of solutions. [17]. The study has explored need of knowledge sharing between building owners and users in decision making. It is recommended that the basis for decision making is further utilised in conjunction with other detailed investigations of building data before evaluation and implementation of building retrofit projects.

The knowledge sharing could could have been a challenge considering the change of building owners and building maintenace personnel during the last 10 years. It could be mentioned here that this is most important barrier to implementation of energy efficient measures and further improvements in energy performance is buildings accurate technical data and regular proactive maintenace of ventilation and heating systems.

The study reveals that though there exists a number of ways to standardize indoor climate control in historical buildings there is shortage of discussion about the decision making process which involves both the building owners and users and using standards which are related to indoor climate control in historical buildings.

Tor Boström et al. 2018 also stated that previous reasearch has shown that risk management guidelines have to be integrated with the building owners existing management decision making processes to be effective else they have a tendency to be live a life of its own detached from the practical reality of situations. The authors highligted the distinction between the intention of applicable standards and the actual use of standards as it is process of interpretation and translation of standard to implementation which is a challenge as each building has its specific present and future specif use. Further it is also mentioned that a dilemma with standardization is the ambition to find a balance between firm advice and flexibility which is part of real life situations as standards are general whereas practice is specific.[15]

Steven Epsttein et al. 2010 concluded with their experience from how standards are used in practice that less stringent standards which offer greater adaptability may work better than rigidly defined standards. This is more relevant to energy performance and building conservation work of historic buildings as the location of a building and the applicable laws and regulations play a crucial role in the organizational decision making processes that form a basis of matrix for decision making on indoor climate and building energy management.[19]

In the present study we have received feedback based on questionaire from the building tenants or users and it is a form of assessment of indoor environment based on users perception. One way of decision making could be tactical improvement to meet the specific applicable work environment standards considering present and intended future use of the building.

It can be concluded in this report that applicable standards and guidelines will be an important deciding criteria for quality assurance in historical buildings energy management and we need to look at multiple factors in building owners decision making process to achieve the present building user indoor comfort levels and implement simplified decision making processes for continuous improvement of indoor climate and building energy management.

6 Conclusions

6.1 Study results

The questionnaire method does not require actual contact with the building users and is a widely used method to collect opinions about the indoor environment which includes air quality, noise situation, indoor temperature and building users perception of building related sickness if any.

Of the total 20 building users 13 responded to the survey. This represents a response rate of 66% which seems acceptable. The data collected from the questionnaire is depicted in a pie chart or bar diagram to see the percentage response.
Three qualitative interviews with building owner, building maintenance personel and supplier of the oil fired boiler was conducted for the study.

The interviews were all connected with the building energy management decision making matrix in the form of risk factors. The aim of the interviews was to explore assessment scales affecting the decision criterias and the outcome of the assessment could be basis for building owners decisions on investments.

As per SS-EN 16883:2017 - SeeAnnexure A an assessment scale is shown below

Table 3 Building owners assessment scale to select packages of measures

Suggested performance improvement measures	High risk	Low risk	Neutral	Low bene fit	High benefit	Building owners decisions including time plan
Energy - High energy use data. Close monitoring during and after office hours to find root cause.	Energy losses. CO_2 emissions not permitted.				High benefit	Could be decided during 2019-20

-Oid fired boiler need to be substituted by either electric heating or district heating system	Energy saving potential. Present boiler is over dimensioned. Boiler manufacturer has stopped supply of reservspares. So maintenace not possible. Building users productivity and morale getting affected due to discomfort and dissatisfaction CO_2 emissions form oil fired boiler User controlled ventilation and heating desired.		Costs could be same considerin g oil and electricity prices. However can meet sustainabil ity & climate goals		High benefit considering climate goals. High benefits considering climate and building heritage goals. Overhaul and adjustments of existing FTX can deliver the desired performance. Beneficial for both building owner and building users. Offers WIN-WIN solutions.	

Indoor air quality	Training of building maintenace staff and installation of monitoring sensors for air flows,				Effective use of Ventilation and heating systems and indirect savings in energy.	
Impact on outer environment	monitoring could increase involvement and feedback on expected air quality from the installed equipments.				Returns on investments.	
Aspects of use	CO_2 Emission reductions Present and future use				High benefit considering building owners strategic plans.	

6.2 Outlook

In Sweden the building blocks has many older residential buildings or historical buildings which often have inadequate building envelopes and poor insulation resulting in high energy use and uncomfortable indoor climate for the building users. Improving energy performance in such buildings by suitable refurbishment measures considering the building owners management process and building user inputs could form a reasonable basis for strategic decisions which are beneficial for both building owners and can have significant impact on the building users comfort requirements. It is a key element in organizations decision making to succeed in prioritizing the energy improvement measures and also meeting the demanding national and EU energy and climate goals.

The building users and their activities in the building including their perceptions of the indoor environment are very important for reducing energy use. However very few studies have focused on end users perspectives and perceptions of the indoor environment. Another advantage of this study is that combining and comparing these factors in decision making assessment scale reveals both way ahead and challenges during the coming years compared with simulation programs which would consider longer life cycle spans and would involve capital intersive investments with inaccurate payback calculations.

6.3 Perspectives

By combining the measurements on site and feedback from both building owners and building users the study had investigated how the buildings energy use and indoor environment can be studied together to arrive at decisions pertaining to measures to improve energy performance of historic building. It is also important to consider the operational costs of such buildings which can typically exceed the construction costs over a life cycle.

On of the most important factor in LCC calculations is the chosen discount rates which depends on the financial situation of the building owner and strategies of the investing company and is always subjective based on inflation and future projections of rents etc. However this choice of discount rates a major impact on LCC ad the optimal solution and package of EEMs included.

The researcher had approached Division of Energy systems, Linköping university to use OPERA-MILP (Optimal Energy retrofits advisory- Mixed integer linear program) to find the cost-optimum energy renovation strategy for this building during its life time. However as this building has a celler or basement and it was not feasible to use OPERA-MILP to determine cost-optimum combination of measures by minimizing LCC. LCC here represents the sum of the investment, running costs and residual value.

It is important to consider the energy efficient measures as a package rather than as individual measures to achieve the energy target. The Energy efficient measures (EEMs) which are included in the package are evaluated as most cost efficient to least cost efficient. In such a EEM package the profitable measures finance the less profitable measures thus making it possible to achieve a well balanced energy use reduction from both the economic and the efficiency point of views.

Knowledge sharing between the building owners and users has not received sufficient attention and suggest that it is the most important barrier to improvement of energy performance of buildings. So this study has been at attempt to use the standard SS-EN 16883:2017 and suggest measures beneficial for both the building owners and users to reach a WIN-WIN situation for both indoor environment control and Energy effective measures to reduce energy demand considering national legislational and standards. The users of the building and their activities and perceptions are important for effective energy use and betterment of indoor environment in historic buildings.

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Appendix

Appendix A

Table 1 Assessment categories and criteria of possible measures

Assessment category	**Assessment criteria**
Technical compatibility	hygrothermal risks
	structural risks
	corrosion risks
	salt reaction risks
	biological risks
Heritage significance of the building and its settings	risk of material, constructional, structural impact
	risk of architectural, aesthetic, visual impact
	risk of spatial impact
Economic viability	capital costs
	operating costs, including maintenance costs
	economic return
	economic savings
Energy	energy performance and operational energy demand in terms of: — primary energy rating (total) — primary energy rating (non-renewable) — primary energy rating (renewable)
	Life cycle energy demand in terms of use of renewable primary energy and nonrenewable primary energy
Indoor environmental quality	indoor environmental conditions suitable for building content preservation
	indoor environmental conditions suitable for building fabric preservation
	Indoor environmental conditions suitable for achieving good occupant comfort levels

	emission of other harmful substances
Impact on the outdoor environment	greenhouse gas emissions from measures implemented and operation
	emission of other harmful substances
	natural resources use
Aspects of use	influence on the use and the users of the building
	consequences of change of use
	consequences of adding new technical room
	ability of building users to manage and operate control systems

Table 2 assessment scale

Assess-ment category	Assess-ment criteria	Suggested performance improvement measures	High risk	Low risk	neutral	Low benefit	High benefit	Owners decision for investments Yes/No	Time plan for implementation

Appendix B

Part 1: Background information – Questionaire

1. How long have you worked in this building?
   - 6 to 12 months
   - 1 to 3 years
   - 4 to 5 years
   - 6 to 10 years
   - More than 10 years

2. State your year of birth. (avoided of date of birth)
   Respondent could answer in figure/text form.

3. How is your workplace?
   - Seperate office room.
   - Share office room with other colleague.
   - Open office space
   - Other not mentioned above

4. On which floor in the building do you have you workspace?
   - Basement
   - Entre floor
   - first floor
   - Second floor
   - Attic or top floor

5. Has your office being painted, or has your room received new wall paper or has flooring in your room replaced during the last five years?
   - Yes
   - No
   - Dont know.

6. Has your workplance any moisture or water leakages during the last five years?

Moisture	Yes	No	dont know
Water leakage	Yes	No	dont know

7. Do you have or have you had

• any form of asthma	Yes	No
• Hay fewer	Yes	No
• Any form av eczema	Yes	No
• Is there any other Collegue who has or has allergies etc.	Yes	No

8. Did you have under the previous period of three months have any of the following symptoms or ailments

Tiredness	Yes, often (every week)	Yes, sometimes	No, Never	If yes, do you think some factors are related to your work environment
Headache				
Itching, pain or eye irritation				
Irritation or running nose				
Dry throat				
coughing				
Dry or red skin on the face				

Part 2: Indoor work environment

Related to Heating and room temperature

9. How do you feel about temperature/heating at your work place?

	Very good	Good	Acceptable	Bad	Very bad
During winter					
During spring					
During Summer					
During autumn					

10. Do you have options to control temperature/heating at your workplace?
    - Yes, I can.
    - Reasonable controls exist
    - No options to influence.

11. Do you experience draught and cold air flow in your workplace?
    - Very much
    - Little
    - Dont know
    - Not at all

12. If you are affected of low pressure and cold air flow please specify where, you may select more than one option
    - at floor level
    - at window level
    - at door
    - at leakages at window or external walls.
    - At ventilationsystems air inflow paths

Air quality

13. What is your feeling about air quality at your work place?
    - Very good
    - Good
    - Acceptable
    - Bad
    - Very bad

14. Do you have any of the following problems at your work place

	Yes, often	Yes ,sometimes	No, Never
Pungent smell			
Mold smell			
Trapped smell			
Stale smell			
Drainage foul smell			
rotten smell			
Exhaust gas smell			
Food waste smell			
Dry air			

15. Can you control ventilation at your workplace?
    - Yes, I can.
    - Reasonable controls exist
    - No options to influence.

Sound level and Illumination

16. Are you disturbed by unnecessary sound at your workplace?

	Yes, often	Yes, sometimes	No, rarely
Ventilation			
Other equipments like washing machines, lift etc			
Sound from vehicle taffic or people outside the building			
Pipes			

17. What do you feel about sound levels or noise at your workplace?
    - Very quiet
    - Quiet
    - Dont know, would like to know the measured results
    - Significant sound levels
    - High sound levels

18. How is the availability of dayligt at your workplace?
    - Very good
    - good

- Dark
- Very dark

19. Are you satisfied or dissatiisfied with the inhouse climate as your work place?
    - Very satisfied
    - Satisfied.
    - Acceptable
    - Neither satisfied or dissatisfied
    - Not satisfied
    - Very dissatisfied
20. Do you have any suggestions for improving energy utilization at your workplace?
    - efficient energy use
    - reduce pollution.
    - Preserve the historical value of the building.
    - Change to renewable energy sources

Appendix C

Swedish standard SS EN 16883:2017
Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings.

SVENSK STANDARD
SS-EN 16883:2017

SWEDISH STANDARDS INSTITUTE

Fastställd/Approved: 2017-06-12
Publicerad/Published: 2017-06-20
Utgåva/Edition: 1
Språk/Language: engelska/English
ICS: 91.120.10; 97.195

Bevarande av kulturarv – Riktlinjer för förbättring av energiprestandan i historiska byggnader

Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings

Appendix D

Energy declaration for Skulptörvägen 8, Johanneshov

Energideklaration för Skulptörvägen 8 , Johanneshov

Detta hus använder 293 kWh/m² och år, varav el 17 kWh/m².
Liknande hus 130 – 195 kWh/m² och år, nya hus 80 kWh/m².
Radonmätning är inte utförd. Ventilationskontrollen är utan anmärkning.
Detaljinformation finns hos byggnadsägaren.
Se även: www.boverket.se/energideklaration
Energideklaration utförd 2012-11-29 av:
Jenny Svahn , Independia Energi AB
Åtgärdsförslag som förbättrar byggnadens
energiprestanda har lämnats.

Boverket

Appendix E

OVK report

VENTMILJÖ

Besiktningsprotokoll

Funktionskontroll av ventilationssystem enligt
BFS 2011:16 OVK1

Referens nr:	Skulptörvägen 8	A
Plats för stämpel	MK VENTMILJÖ Box 5018 141 05 Kungens Kurva Tel/fax 08-88 74 70	

A1 - Byggnad

Fastighetsbeteckning	Byggnadens adress	Postnr	Ort
Bysten 1	Skulptörvägen 8	121 43	Johanneshov
Byggnadsägaren	**Postadress**	**Postnr**	**Ort**
Specialboende i Stockholm AB	BOX 3122	169 03	Solna
Faktureringsadress	**Postadress**	**Postnr**	**Ort**
Specialboende i Stockholm AB	BOX 3122	169 03	Solna

Fastighetsansvarig/Förvaltare	Telefonnr	Fax / e-post

Internt byggnadsnamn	Internt byggnadsnr	Verksamhet	BRA i m^2	Ant. Lgh	Ant. lokaler
Specilaboende	1	Psykiatri			1

A2 - Besiktningsutlåtande (+ sammanställning av system inom byggnaden)

Systemnr	Bes.kat.	Besiktningsdatum	Besiktnings resultat	Ombesiktning datum	Nästa ordinarie besiktningsdatum	Bilaga (B-sida)	Notering
1	1	2017-12-15	G		2020-12-15	B1	

Rum. nr.	Benämning	Projekterad Tilluft	Uppmätt Tilluft	% av proj Tilluft	Mät-metod	Projekterad Frånluft	Uppmätt Frånluft	% avproj Frånluft	Mät-metod	Anm.
206	WC					20	20	100	B3	
204	Förrum					60	60	100	B3	
211/212	Rum	100	100	100	B3					
208			10		B3					
209	Rum	40	40	100	B3					
204	Förrum					60	59	98	B3	
205	WC					20	20	100	B3	
203	Kök					60	60	100	B3	
201	Café	80	78	98	B3					
213	Reception	40	40	100	B3					
403	WC					20	20	100	B3	
404	Förrum					60	60	100	B3	
401	Projektledning	80	80	100	B3					
411	Rum	20	20	100	B3					
407	Förrum					60	60	100	B3	
302	Kontor						45		B3	