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Savings for Retail Properties through Active Energy Management

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Abstract—**The built environment accounts for 40% of the total energy consumption and CO2 emissions in Europe. Furthermore, the majority of environmental impacts of properties are generated during the operation phase of the building. Increasing energy efficiency through energy management could offer an effective solution to managing the CO2 emissions of a building through its life cycle. Building automation systems are linked with energy consuming building systems and with appropriate monitoring and control offer potential for energy efficiency improvements and energy and CO2 savings. The purpose of this study is to present a simple and effective approach to building energy efficiency by optimizing building processes throughout the operating phase of the building. This study describes the function of a remote energy management control center and presents the benefits it can bring for the environment, property owner and property user. The study is conducted using case study methodology. The case under review is a remote energy management control center operating under the service portfolio of a global commercial facility services provider. A data sample of the energy consumption of 44 retail properties was analyzed. Additional data collection methods included observation and interviews. The study shows that consumption of electricity can be decreased by 4.85% and heating energy by 6.73%, totaling 2458 ton reduction in CO2 emissions and 695,981 €, via the implementation of a continuous and regular energy monitoring and control of building systems and equipment. Further analysis show that the decrease will continue in the future.**

Keywords- energy management, building automation, energy conservation, retail sector, operating phase

I. Introduction

The European Union is committed to reducing its green house gas emission by 20% and energy consumption by 20 % by 2020, compared to the levels of 1990 [1]. When roughly 40% both of the total energy consumption and the carbon dioxide emissions in Europe are accounted for by the built environment [2], [3], it becomes imperative to involve the building sector in the fight against the climate change. As such, reducing the environmental impacts of buildings represents significant potential.

As ca. 80-90% of the environmental impacts of buildings are generated during the operating phase [4], [5], focus should be on managing the environmental impacts during that time. Moreover, the existing commercial buildings will continue to represent the majority of the commercial building stock far into the future. Notwithstanding, research and discussion associated with environmental performance of commercial buildings has mainly focused on the building technologies and construction of new buildings.

The building sector can be divided into residential and commercial buildings. The commercial sector includes, for example, retail, office, hotel and education facilities. Retail sector equals to 24% of the total non-residential sector and accounts for 23% of the total energy consumption of the non-residential sector [6]. During the recent years, significant changes have happened in the retail sector in Finland [7], i.e. chain stores have become more common, the unit size of stores has grown, and international competition has increased.

Increasing energy efficiency is one of the key actions to reduce emissions of greenhouse gases throughout the life cycle of the building [8]. Energy efficiency measures include improved energy management and energy conservation. However, there are barriers that can prevent the implementation of energy efficient practices [6]. Such barriers include the perception that sustainable design implies additional costs, or that energy efficient technologies may have higher initial cost, even though the payback time can be relatively short. The lack of information can also be a major obstacle for implementing energy efficiency measures.

Energy management can be defined as "systematic quantification of energy-related activities within a system boundary, e.g. site, a region or a product" [9]. It includes the process of monitoring, controlling, and conserving energy in a building or organization. Thus, building automation systems are an integral part of it.

Building automation systems have traditionally been seen as a technical tool for narrow areas of energy management, security or environmental control [10]. The key driver of building automation systems has been increased occupant comfort and reduced operation cost [11]. This has generalized the controlling of heating, ventilating, air-conditioning systems and lighting through building automation systems. Improvements in energy efficiency have also become a means to environmental protection. Furthermore, the authors suggest that a centralized monitoring and control center can aid in reducing costs, especially when a remote access to the site is possible.

The purpose of this study is to present a simple and effective approach to building energy efficiency, by optimizing building processes throughout the operating phase of the building. This study describes the function of a remote energy management control centre and presents the benefits it can bring for the environment, property owner and property user. Hypothesis is that active, continuous and regular building automation system control and management provides excellent results both in energy consumption and indoor conditions.

Following this introduction, Section II – Study Design describes the research approach and methodology and presents the case in question. Section III- Results presents and analyses the major findings. Finally, Section IV Discussion and Conclusions discusses the findings further, draws conclusions, and provides recommendations for the future research.

II. Study Design

The study is conducted using case study methodology. A single-case study is used in order to retrieve detailed empirical data on the studied phenomenon in real-life context [12]. The case under review is a remote energy management control center operating under the service portfolio of a global commercial facility services provider. Remote energy management controlling means a centralized building automation system control center, which is specialized in active energy management. A data sample of the energy consumption of 44 retail properties was analyzed. Additional data collection methods included observation and interviews. The operations, function and general benefits of the remote energy management control center were discovered by interviewing the customer service manager and the director of energy management, and also observing the operations in the remote control center. The concrete benefits were discovered by analyzing the consumption data of a property sample connected to the service.

The studied service is an integral part of the energy management and consumption monitoring process of the service provider, which comprises different aspects of property maintenance, technical services, alarm control center, help desk, and other supporting services. It is noteworthy to mention that the remote energy management control center acts as a supporting tool for the property maintenance and technical property services for all properties connected to it, not as a separate service. It is responsible for the use and energy management of building services in co-operation with the on-site building maintenance. The goal is to unify and modernize the building automation system operations of all the properties under the maintenance of the facility service providers by centralized control and monitoring as energy efficiently as possible while still maintaining high level operations and occupant comfort.

The remote energy management control center provides extensive energy management – continuous regular monitoring by professionals in order to control the customers' energy consumption and costs. At the same time, indoor conditions of the building are optimized to be appropriate. The monitoring solutions are based on the needs of the customer. All commonly used building automation system software can be connected to the service. Control systems for all of the equipment can be centralized; building automation system, ventilation, air-conditioning, heating, cooling, lighting and refrigeration. Energy, deviation, and maintenance reports and proposals for action are delivered from the remote control center on a scheduled date to the owner and the facility manager.

A. Process description

The professionals at the remote energy management control center check the set point values and controls of all of the building systems regularly, in a weekly cycle. This allows for quick reaction to possible deviations. The operating schedules are optimized continuously, for example weather changes are managed proactively at all times. Optimization of the system schedules is also possible by measurements, for example CO2, or temperature based air conditioning, lighting adjusted according to customer needs and motion detectors and outdoor lighting controlled by photoelectric switches.

Local operations are daily carried out by onsite building maintenance personnel. Typical operations of the remote control center include monitoring and optimizing of the operating schedules and set point values. At the same time, possible improvements and investment suggestions are collected. When a new property is connected to the service, checking and optimizing of the set point values and controls is commenced. Based on the checks, the local property maintenance organization is given action and improvement suggestions regarding the systems and maintenance. These are continued regularly during the service period. Energy savings and improvement suggestions are primarily given on low- or no-cost systems or operations. In this way larger investments and payback times are advanced methodically. Typical problems found within the remote control center include, for example, leaking valves and simultaneous heating and cooling.

Typical smaller investments include automation program changes or adding sensors. Larger investment suggestions are, for example, implementation of recirculation air use, which can bring significant savings in heating, CO2-based ventilation, heat recovery from exhaust air or exploiting free condensate heat from refrigerating equipment.

III. Results

The original data sample was 44 properties. However, seven properties were excluded from the data. The excluded data was considered incomparable with the other properties. One of the excluded properties had undergone a major building extension during the reference period, one had substantial changes in the energy metering; it went from store specific metering to whole building metering, and one went through a major building automation renovation. The purpose of use and stock of equipment had changed in three properties and one had major additions in the stock of equipment during the reference period.

Table 1 shows the energy consumption levels of the remaining 37 retail properties all around Finland. The data was collected in an 18-month period, starting on the date when the properties were connected to the service. The comparison period is the 12-month period before connecting to the service. As a total result, electricity consumption decreased 4.85% and heating energy 6.73% on the average during the reference period. Furthermore, the results show that even over 20% reduction of electricity consumption and over 40% reduction of heating energy consumption can be achieved. The total decrease in CO_2 emissions was 2458 ton. CO_2 emissions were calculated using the average values of the Finnish energy production. This study does not take into account the company specific CO_2 emission discharge levels of energy providers, since the sample represents facilities throughout the country and the information on the respective energy companies was not readily available. The values used were 280 kg(CO_2)/MWh for electricity and 219 kg(CO_2)/MWh for district heating [2]. Monetary savings from electricity reduction were 510,589 € and from heating energy reduction 185,392 € during the reference period. Unit prices used were 85.1 €/MWh for electricity [13] and 52.18 €/MWh for heating energy respectively [14].

However, even in the remainder of the data, 9% increase in electricity consumption and over 17% increase in heating energy consumption can be seen in a few properties. Possible explanations for the increase in energy consumption include the owners' unwillingness to invest in the suggested improvements, increases in the number and volume of refrigerating units or increased cooling demand associated with unusually warm weather. Another potential reason for the increased energy consumption in some units is the law passed in Finland in 2010 allowing for retail stores to stay open on Sundays.

Several economical benefits could be gained through a remote control center. Savings can be accomplished with quick reaction to problems and proactive response to weather changes. Real time monitoring and continuous leakage watch are possible, and continuous monitoring can provide a permanent decline in energy consumption levels. Furthermore, immediate, concrete results are possible to see from hourly-based real time measurements.

There can be functional benefits from the use of the remote control center, in addition to the economical. Information backups are handled systematically and automatically. Quick reaction to problem situations prevents the matter from escalating into serious problems or energy consumption increase. Deviations are recorded and documented and all equipment alarms leave historical data. Energy reports are compiled from a single source, investment and action proposals are included. Only one contact is needed in guiding the operations of the property. Energy management is provided jointly form professionals, with the latest technology in use. Information flow becomes easier, from service provider to property owner to occupants. Connections to properties are controlled and secured. In co-operation with the service provider additional alteration works can be handled quickly and in a straightforward manner in-house. Owing to the nationwide scope, monitoring and reporting is consistent throughout the whole portfolio. Best professional skill is always present and the same agreed operations model is used no matter where the property is located. The agreed reports are delivered on the agreed date.

The energy management service aims at continuous improvement. When examining the last six month period and comparing it to the consumption levels of the previous calendar year, i.e. when the properties were already connected to the remote control center, the results show that the consumption levels continue to decrease. Total electricity consumption decrease during the last six months of the reference period was 4.26 % and heating energy decrease 5.34 % on the average. This shows that the remote energy management continues to affect the performance of the building, even after the initial improvements.

TABLE I. CONSUMPTION DATA

		Electricity					**Heating energy**				
Case	Volume m^3	Comparison period MWh	Reference period MWH	Change MWh	Change %	CO2 tons	Comparison period MWh	Reference period MWH	Change MWh	Change %	CO2 tons
1	92012	7170	6594	-576	-8.03 %	-161	1389	1137	-252	-18.17 %	-55
2	62350	6919	6280	-638	-9.23 %	-179	1943	1542	-401	-20.62 %	-88
3	43070	4892	4590	-302	-6.18 %	-85	960	960	0	*0.03 %*	0
4	60990	4396	4108	-287	-6.54 %	-80	612	648	36	*5.90 %*	8
5	9500	2778	2653	-125	-4.51 %	-35	810	673	-138	-16.98 %	-30
6	5290	1689	1636	-53	-3.15 %	-15	472	316	-156	-33.14 %	-34
7	11000	2295	2235	-60	-2.60 %	-17	560	530	-30	-5.34 %	-7
8	NA	193	165	-28	-14.67 %	-8	NA	NA	NA	NA	NA
9	27644	1734	1624	-110	-6.34 %	-31	970	644	-326	-33.58 %	-71
10	4880	713	713	0	-0.07 %	0	104	97	-8	-7.21 %	-2
11	11425	1695	1620	-76	-4.48 %	-21	248	237	-11	-4.31 %	-2

12	14500	2063	2048	-15	-0.72 %	-4	NA	NA	NA	NA	NA
13	12020	2280	2364	84	3.66 %	23	384	414	30	*7.92 %*	7
14	6850	1659	1560	-99	-5.96 %	-28	587	301	-286	-48.71 %	-63
15	7270	1680	1619	-62	-3.66 %	-17	668	414	-254	-38.07 %	-56
16	11800	1846	1741	-105	-5.71 %	-30	234	229	-6	-2.35 %	-1
17	4960	713	721	8	*1.09 %*	2	492	325	-167	-33.98 %	-37
18	NA	1026	1062	35	*3.43 %*	10	1741	1539	-202	-11.63 %	-44
19	NA	1366	1258	-108	-7.92 %	-30	NA	NA	NA	NA	NA
20	3200	927	942	15	*1.67 %*	4	NA	NA	NA	NA	NA
21	150558	4932	3917	-1015	-20.58 %	-284	2674	2669	-5	-0.18 %	-1
22	42000	1538	1425	-113	-7.33 %	-32	1865	1719	-146	-7.81 %	-32
23	NA	830	740	-90	-10.86 %	-25	2902	2720	-186	-6.42 %	-41
24	149480	12196	12082	-114	-0.93 %	-32	5075	5464	389	*7.66 %*	85
25	76100	3920	3992	73	1.85 %	20	1409	1472	63	*4.47 %*	14
26	80318	5401	5892	491	*9.08 %*	137	1961	1968	7	0.34 %	1
27	11000	6433	5886	-546	-8.50 %	-153	1401	1301	-100	-7.12 %	-22
28	NA	5427	5209	-217	-4.00 %	-61	1123	1117	-7	-0.58 %	-1
29	115300	7962	7578	-384	-4.83 %	-108	2836	3140	305	*10.74 %*	67
30	120730	3011	2893	-118	-3.92 %	-33	1549	1592	42	*2.74 %*	9
31	NA	1901	2269	113	*5.94 %*	32	603	583	-84	-13.97 %	-18
32	96000	6516	5874	-642	-9.85 %	-180	1656	1946	290	*17.53 %*	64
33	NA	4906	4386	-521	-10.61 %	-146	3058	2459	-600	-19.61 %	-131
34	109353	4010	3664	-346	-8.62 %	-97	5213	4729	-484	-9.28 %	-106
35	NA	759	768	8	*1.10 %*	2	1040	984	-57	-5.46 %	-12
36	NA	5345	5259	-85	-1.59 %	-24	6224	5412	-812	-13.05 %	-178
37	1578	610	620	10	*1.71 %*	3	NA	NA	NA	NA	NA
	TOTAL	**123729**	**117985**	**-6000**	**-4.85 %**	**-1680**	**52763**	**49279**	**-3553**	**-6.73 %**	**-778**

Cases 1-20: Comparison period 1.6.2006-30.11.2007, Reference period 1.6.2007-30.11.2008

Cases 21-37: Comparison period 1.1.2008-31.6.2009, Reference period 1.1.2009-31.6.2010

IV. Discussion and Conclusions

It has been widely acknowledged that the built environment plays a major role in fighting climate change and delivering a sustainable economy. The built environment accounts for roughly 40 % of both the total energy consumption and the carbon dioxide emissions globally. Furthermore, it is estimated that approximately 80% of the carbon emissions caused by buildings are created during the operating phase of the existing buildings, making the topic of this research both relevant and current. The initial hypothesis was that remote energy management could significantly reduce the energy consumption and CO2 emissions in retail properties.

The study shows that consumption of electricity can be decreased by 4.85% and heating energy by 6.73%, totalling 2458 ton reduction in CO2 emissions and 695,981 €, via the implementation of a continuous and regular energy monitoring and control of building systems and equipment. Further analysis show that the decrease will continue in the future. However, it should be noted that the results heavily depend on the characteristics of the property in question and the willingness of the owner to invest in improvements. The data sample of this study, 44 retail properties, show a portion of the 160 buildings altogether connected to the service, representing 28% of the whole.

The remote management control room also provides benefits beyond the economical. Information flow becomes smoother due to the centralized and cooperation based building management and maintenance practices. Indoor conditions are maintained and effort is put to training needs of both the maintenance personnel and the occupants.

As the retail industry is a growing industry with increasing unit size, significant potential exists for efficient energy management. However, similar savings are also potential for other building types, such as offices. Future research could focus on other building types. This study shows the environmental and economical benefits of remote energy management controlling, further studies could, however, also involve the environmental impacts of the remote control center.

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