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BUSINESS INFORMATION SYSTEMS AS A SUPPORT FOR ANALYZING ENERGY EFFICIENCY OF HEALTHCARE ORGANIZATIONS

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Abstract: *Business information systems and their software solutions are often used as a tool for analyzing the energy efficiency of certain objects. In this way, by simulating and optimizing and applying the concept of "smart" objects, we can easily evaluate the existing one and provide a proposal for improving energy efficiency. Using such tools we can very precisely determine the values of individual parameters that would lead to significant savings in energy consumption, using alternative resources. In this paper the energy efficiency of the Clinical Center in Niš will be analyzed and will be given proposals for improving energy savings through the software RETScreen.*

Keywords*: information systems, healthcare, organization, energy efficiency.*

1. Introduction

Over the past years, interest in finding solutions that reduce unnecessary energy consumption by certain buildings has been increased given that benefits such as financial and ecological. Namely, the economic advantages of energy savings and long-term ecological sustainability occur due to the use of an adequate type of material in the construction of buildings themselves, as well as by respecting all natural characteristics of the environment, with the proper use and allocation of resources which generate energy. The role of business information systems in this field is to provide software support by which entering data and parameter values into a computer program, it is possible to accurately propose solutions for energy savings and its rational spending.

This is primarily reflected in the design of the "smart home" concept, which represents the management of the buildings energy characteristics, using artificial ambient

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intelligence provided by information systems in the energy sector. In this way, from a financial and ecological point of view, it is recommended to achieve a satisfactory level of energy efficiency when it comes to the given characteristics of the construction object.

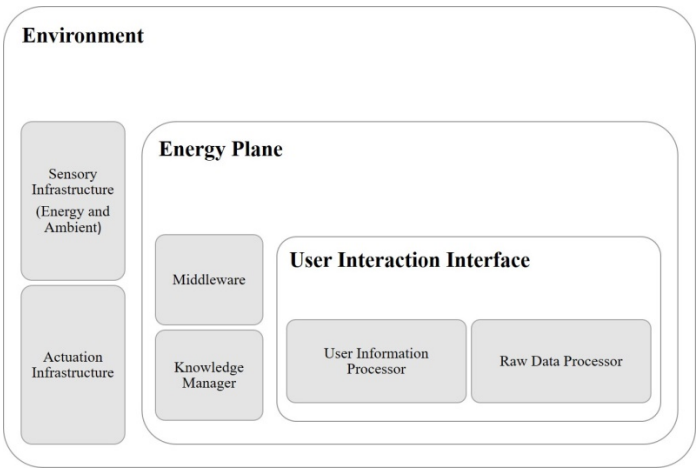
Consequently, this paper will discuss the role of business information systems in evaluating energy efficiency even at a distance. Also, through the RETScreen software, the existing energy efficiency of the Clinical Center in Niš will be analyzed, based on its surface and construction characteristics, as well as the use of electricity and heating and cooling systems, and proposing more efficient solutions in order to save energy.

2. Business information systems as a tool for analyzing buildings energy efficiency

The role of business information systems when we are talking about energy savings (electrical, heat ...) and more efficient use of resources which produces it, is not related exclusively to the economic aspect. Namely, business information systems with their software solutions, and more recently electronic platforms for analyzing energy consumption (Google PowerMeter, AlertMe, E2Home) create a so-called "eco-friendly" atmosphere (De Paola et al., 2014). This "eco-frendly" concept is part of the already mentioned smart home paradigm that raises awareness of the significance of energy efficiency among users, with electronic feedback of energy consumption, and improves the allocation of resources.

On the other hand, the heterogeneity of software solutions for energy efficiency monitoring aims to reduce potential uniqueness in evaluating energy efficiency, since the environment, resources and the way of energy use are different because of the facility purpose. However, all software solutions have in common electronic infrastructure (Figure 1) which is used to monitor energy efficiency and which aims to increase interoperability in assessing the energy performance of facilities.

Figure 1: Electronic infrastructure of energy efficiency software solution



Source: Authors

Accordingly, business information systems enable the reduction of energy costs as well as the reduction of costs which resulting from inadequate use of energy resources and inadequate construction and positioning of facilities. This implies respect for the environmental and energy characteristics of the material and the climatic characteristics of the environment in which the facility is located. Also, when the electricity is concerned and the costs arising from its use, the so-called stand by electricity consumption, should be reduced. Namely, many devices inside and on buildings consume electricity even they are not handled, but still connected to an electrical network. Therefore, business information systems, in order to reduce energy costs, monitor electronically on energy consumption and make benchmarking with similar facilities that generate savings on this issue. Monitoring is reflected in the following (De Paola et al., 2014):

- Satellite recording and monitoring of environmental conditions - climate, temperature, lighting.
- Monitoring energy consumption.
- Adaptation to existing environmental conditions from the environment by computer simulation.
- Interaction with energy users by sending notifications of current energy efficiency.
- Predicting the financial and ecological effects that result from current energy consumption.
- Costs projection and forecasting.
- Forming a model for more efficient use of energy resources.

3. RETScreen software for energy efficiency evaluation of Clinical Center in Niš

A big challenge in the construction industry, both from a cost and energy perspective, is building "smart" energy-efficient facilities, which will have their own electronic control system. In this way, it is possible to monitor and minimize energy consumption without the feeling of dissatisfaction with the users. Facilities have exceptional potential for generating positive energy effects if their construction and shape are adapted to the nature, environment and purpose of these facilities. Consequently, the development of intelligent software control and predictive solutions, which simulate the performance of facilities in order to improve their energy efficiency. This is because in developed countries 47% of national energy consumption comes from buildings (Lalita et al, 2013).

One of these solutions is RETScreen, which, based on the parameters and characteristics of potential or existing facilities, as well as the comparison of facilities, offers a proposal for the best or optimal energy alternative. Also, with this software, proposals for reducing the cost component by energy conservation of the thermal, air and light elements of buildings are given. RETScreen is able to electronically transcribe satellite data, collect energy data from databases and facilities, and analyze, predict, and forecast

their long-term energy consumption, with suggestions on possible corrections within the facility to save energy (Lalite et al., 2013).

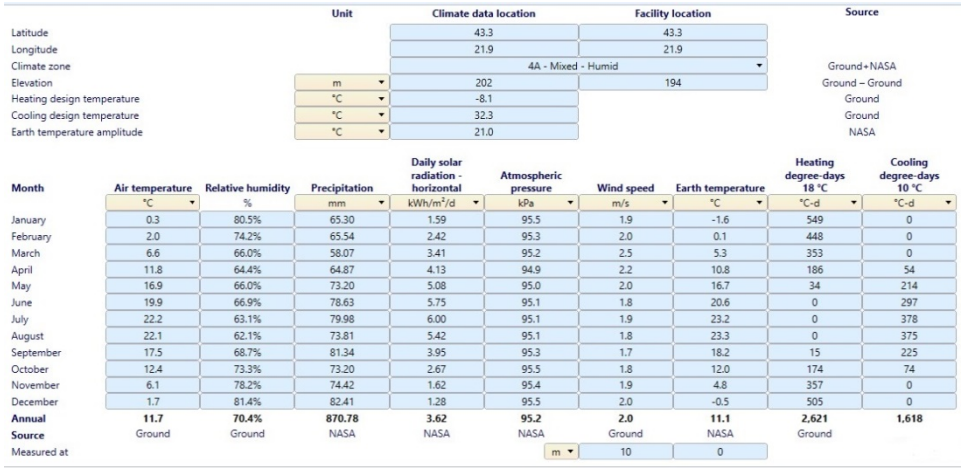
Based on the Energy Performance Index (EPI), the software performs an assessment of the facility efficiency based on its square footage and the recommended energy consumption in kWh / m^2. When it comes to the Clinical Center in Nis, its area is 44,450 m^2, with the recommended energy consumption for a facility of this size with all accompanying medical equipment, staff and patients of 190 kWh / m^2. If an existing energy consumption scheme is adopted, this facility would have an energy consumption of 229 kWh / m^2, which is 17% more than the proposed software consumption.

Figure 2: Based and proposed case of Clinical Center energy consumption

Source: Authors

In order to make the analysis of the energy consumption of the said health institution, it is necessary to take into account the climatic conditions in which such energy consumption takes place, such as climate zone, humidity, temperature, number of sunny days, radiation, atmospheric pressure, etc. Specifically, RETScreen via satellite collects climatic data for the given area, in this case for the area of the city of Niš (Figure 3). Accordingly, the software provides suggestions for possible reduction of energy consumption.

Figure 3: Climatic conditions in Niš



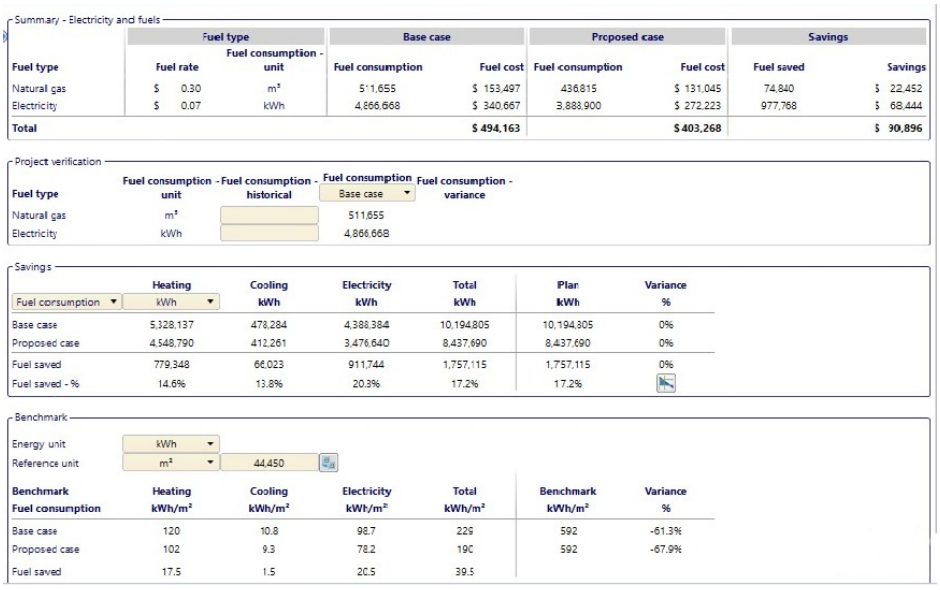
	Unit	Climate data location	Facility location	Source
Latitude		43.3	43.3	
Longitude		21.9	21.9	
Climate zone		4A - Mixed - Humid		Ground+NASA
Elevation	m	202	194	Ground – Ground
Heating design temperature	°C	-8.1		Ground
Cooling design temperature	°C	32.3		Ground
Earth temperature amplitude	°C	21.0		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	0.3	80.5%	65.30	1.59	95.5	1.9	-1.6	549	0
February	2.0	74.2%	65.54	2.42	95.3	2.0	0.1	448	0
March	6.6	66.0%	58.07	3.41	95.2	2.5	5.3	353	0
April	11.8	64.4%	64.87	4.13	94.9	2.2	10.8	186	54
May	16.9	66.0%	73.20	5.08	95.0	2.0	16.7	34	214
June	19.9	66.9%	78.63	5.75	95.1	1.8	20.6	0	297
July	22.2	63.1%	79.98	6.00	95.1	1.9	23.2	0	378
August	22.1	62.1%	73.81	5.42	95.1	1.8	23.3	0	375
September	17.5	68.7%	81.34	3.95	95.3	1.7	18.2	15	225
October	12.4	73.3%	73.20	2.67	95.5	1.8	12.0	174	74
November	6.1	78.2%	74.42	1.62	95.4	1.9	4.8	357	0
December	1.7	81.4%	82.41	1.28	95.5	2.0	-0.5	505	0
Annual	**11.7**	**70.4%**	**870.78**	**3.62**	**95.2**	**2.0**	**11.1**	**2,621**	**1,618**
Source	Ground	Ground	NASA	NASA	NASA	Ground	NASA	Ground	
Measured at					m	10	0		

*Source:*Authors

In order to properly assess the energy efficiency of a healthcare facility, such as the Clinical Center in Niš, it is necessary to enter data in the software, the type of fuel used for energy production (heating and cooling per m3) and the amount of electricity expressed in kWh and their prices. As can be seen from Figure 4 this healthcare facility uses natural gas at a price of $ 0.3 per m^3 of gas while electricity is charged at a price of $ 0.07 per kWh.

Figure 4: Fuel consumption and proposed savings of Clinical Center in Niš



Summary - Electricity and fuels

	Fuel type			Base case		Proposed case		Savings	
Fuel type	Fuel rate		Fuel consumption - unit	Fuel consumption	Fuel cost	Fuel consumption	Fuel cost	Fuel saved	Savings
Natural gas	$	0.30	m³	511,655	$ 153,497	436,815	$ 131,045	74,840	$ 22,452
Electricity	$	0.07	kWh	4,866,668	$ 340,667	3,888,900	$ 272,223	977,768	$ 68,444
Total					**$ 494,163**		**$ 403,268**		**$ 90,896**

Project verification

Fuel type	Fuel consumption - unit	Fuel consumption - historical	Fuel consumption Base case	Fuel consumption - variance
Natural gas	m³		511,655	
Electricity	kWh		4,866,668	

Savings

Fuel consumption	Heating kWh	Cooling kWh	Electricity kWh	Total kWh	Plan kWh	Variance %
Base case	5,328,137	478,284	4,388,384	10,194,805	10,194,805	0%
Proposed case	4,548,790	412,261	3,476,640	8,437,690	8,437,690	0%
Fuel saved	779,348	66,023	911,744	1,757,115	1,757,115	0%
Fuel saved - %	14.6%	13.8%	20.3%	17.2%	17.2%	

Benchmark

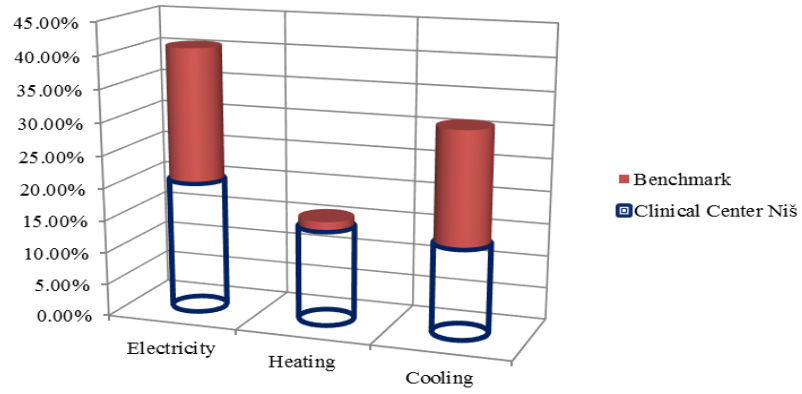
Energy unit: kWh
Reference unit: m² 44,450

Benchmark Fuel consumption	Heating kWh/m²	Cooling kWh/m²	Electricity kWh/m²	Total kWh/m²	Benchmark kWh/m²	Variance %
Base case	120	10.8	98.7	229	592	-61.3%
Proposed case	102	9.3	78.2	190	592	-67.9%
Fuel saved	17.5	1.5	20.5	39.5		

Source: Authors

If the proposals of RETScreen software for the heating process were respected, they would save 14.6%, for the cooling process 13.8% while the electricity savings would be 20.3% annually (Figure 4). As noted above, in addition to the energy saving suggestion, RETScreen also provides the possibility for some kind of benchmarking of energy consumption with the most similar objects, according to the energy characteristics nearby (Figure 5). It can be concluded that the position of the Clinical Center and microclays correspond to lower energy consumption when it comes to the cooling system.

Figure 5: Energy consumption comparison of Clinical Center in Niš and its benchmark



Source: Authors

After previously analyzing energy consumption, RETScreen software provides suggestions for improving the existing energy system of the Clinical Center. In order to achieve even greater energy savings and thus reduce costs, it is necessary to invest in additional adaptation of the facility in some of its sectors and equipment, which would increase the chance for further savings (Table 1).

Table 1: Proposals for energy improvements of Clinical Center in Niš using RETScreen

Section	Requirements for energy savings
Schedules	- Adjust temperature settings.
Building envelope	- Install new blinds on windows.
Ventilation	- Exhaust fans: Replace existing exhaust fans with high efficiency units.
Lights	- Install LED lamps. O&M savings due to longer life expectancy of LEDs. - Install occupancy sensors.

Electrical equipment	- Computer: Train staff to turn off and use the stand-by feature. - Vending machines: Switch to more efficient equipment. - Kitchen - Coffee brewer and warmer: Switch to airpot coffee brewer, which doesn't require a coffee warmer. - Kitchen - Holding cabinet: Switch to more efficient equipment. - Kitchen - Refrigerator (Reach-in and undercounter): Switch to more efficient equipment. - Kitchen - Freezer (Reach-in and undercounter): Switch to more efficient equipment. - Standby losses: Install power bars and train staff to shut down properly.
Hot water	- Patient room and washroom: Reduce water usage by 20%. O&M savings due to reduced water usage. - Restaurant: Install new dishwasher. Reduce water usage by 15%. O&M savings due to reduced water usage. - Install drainwater heat exchanger.
Fans	- Parking garage: Install demand-controlled ventilation system based on CO emissions.
Pumps	- Domestic cold water booster pump: Install new motors with variable speed drive.
Process heat	- Griddle: Switch to more efficient equipment. Turn off equipment when not in use. - Fryer, Broiler and Range: Turn off equipment when not in use. - Steamer: Switch to more efficient equipment. Turn off equipment when not in use. O&M savings due to reduced water usage.
Other opportunity - Solar water heater	- Install solar water heating system (minimum of two solar collectors).
Other opportunity - Photovoltaic	- Install photovoltaic power system (solar collectors = maximum 25% of roof area).

Source: Authors

4. Conclusion

The multidisciplinary approach of business information systems to the energy efficiency analysis contributes to the development of new solutions for energy saving in all fields. Business information systems and their software solutions, such as RETScreen, provide suggestions for cost reduction when it comes to using energy from certain institutional, commercial and industrial facilities. Satellite data collection as well as entering data of energy characteristics of existing and potential facilities can be projected energy efficient facilities. This not only contributes to better management of financial resources when it comes to energy savings, but also to the preservation of the environment.

The symbiosis of business information systems and energy resource management has the potential to create a new economic discipline that will deal with the energy savings of the mentioned facilities. Consequently, a "neural network" concept of energy resources management is being developed with software to save energy. After evaluating the energy characteristics through RETScreen on the example of the Clinical Center in Niš, as one of

the future major consumers, it can be concluded that improvements in energy savings are always needed. Although seemingly incremental energy changes, long-term energy savings can occur.

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POSLOVNI INFORMACIONI SISTEMI KAO PODRŠKA ANALIZI ENERGETSKE EFIKASNOSTI ZDRAVSTVENIH ORGANIZACIJA

Apstrakt: Poslovni informacioni sistemi i njihova softverska rešenja često se koriste kao svojevrsni alat za analizu energetske efikasnosti određenih objekata. Na ovaj način se simulacijom i optimizacijom uz primenu koncepta „pametnih“ objekata može lako evaluirati postojeća i dati predlog za poboljšanje energetske efikasnosti. Korišćenjem ovakvih alata mogu se veoma precizno odrediti vrednosti pojedinih parametara koje bi dovele do značajne uštede u potrošnji energije, upotrebom alternativnih resursa. U ovom radu biće analizirana energetska efikasnost Kliničkog centra u Nišu i dati predlozi za unapređenje iste i uštedu energije putem softvera RETScreen.

Ključne reči: informacioni sistemi, zdravstvo, organizacija, energetska efikasnost.