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PRIMJENA INFORMACIJSKOG SUSTAVA BAZIRANOG NA EKSPERTNIM SUSTAVIMA ZA POBOLJŠANJE ENERGETSKE UČINKOVITOSTI

APPLYING OF INFORMATION SYSTEMS BASED ON EXPERT SYSTEMS FOR ENERGY EFFICIENCY IMPROVEMENT

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Ključne riječi: stakleнički plinovi, obnovljivi izvori energije, energetska učinkovitost.

Keywords: greenhouse gases, renewable energy sources, energy efficiency.

Sažetak:
U radu je prikazana mogućnost korištenja Informatičke tehnologije za izračune financijskih i energetskih ušteda korištenjem nisko energetskih uređaja i obnovljivih izvora energije. Za primjer je uzet objekt kojem je za sustav grijanja i pripremu sanitarne vode potrebna toplinska snaga od oko 500 kW. Analizirani su sustavi plinskog grijanja, daljinskog odnosno vrelovodnog grijanja, solarnog i mogućnost korištenja topline zemljine kore. Cilja rada je bio na jednostavan način, korištenjem Informatičke tehnologije, pokazati krajnjem korisniku omjer uloženog i dobivenog u nisko energetske uređaje i obnovljive izvore energije. Također kao izlazni podatak bilo je bitno pokazati vrijeme povrata investicije ulaganjem u uređaje koji štede energiju, smanjuju emisiju staklenićnih plinova i obnovljive izvore energije u vrijeme kada je energije sve manje i ekološki pokazatelji znatno lošiji od predviđenih.

Abstract:
This paper shows how to use Informatical Technology for calculating financial and energy raw materials saves using low energy devices and renewable energy. For example is taken one object that needs 500 kW heating energy for heating and preparation hot domestic water. Gas heating, district heating net, opportunity solar energy and constant temperature of earth crust will be analyzed. The article goal is through using of informatics technology show to end user ratio between invested and saved using low energy devices and renewable energy. Return of investment in saves energy devices is one of the most important output information.

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1. INTRODUCTION

Energy has become very important political issue with goods reasons. Modern society depends on energy. Safe supplying with cheap fuel has to determine prosperity of billions of human beings. To satisfy necessity of increasing needs the world has to have production of much more energy. However, it is not possible to produce huge amount of fossil fuel or replicable non-renewable uranium (sources that cover 90% of today's energetic needs). Figure 1. [1] shows oil finding site and spending projection.

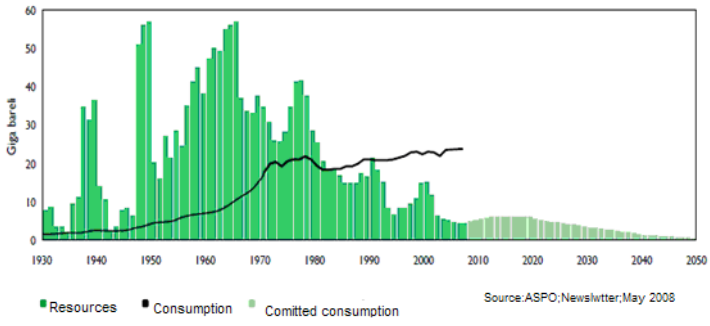

Figure 1. Oil finding sites and projection of spending [1]

Last few years the oil prices vertiginously increased started with 24$ per barrel at the begging of 2003.till over 140$ per barrel in August 2008. which represents figure 2. [2]

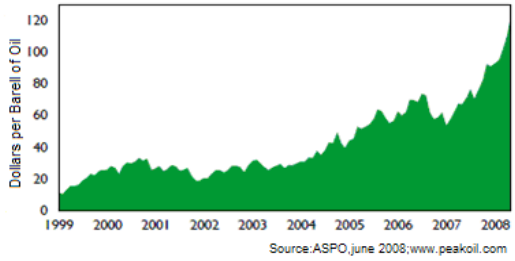

Figure 2. Price of raw oil consumption [2]

Gas crises showed how economy can be vulnerable because of conflicts which all the time endanger necessary and safely energy supplying. It was thought that coal will be long term energy source when oil and gas disappeared. Using of coal realised huge amount of carbon dioxide. Chine as one of the biggest coal producer has started to import coal at the beginning of 2007. Nuclear energy decreases reserve of cheap uranium, the price is increasing, and discussion about safety has not stopped. Renewable energy sources are necessary but these sources can not be competent to fossil fuel according to price, arrangements and efficiency degree. In 2007. European Union decided to improve energy efficiency for 20 % till the end of 2020. Chinese government has intention to increase energy efficiency for 20 % in five years. Even, the biggest world energy consumer USA tries to decrease dissipation of energy and import of emergent from Middle East for 75% before 2025.

To achieve energy efficiency the logic start is increasing of efficiency in buildings. Buildings spent approximately 40% of overall energy in Europe and USA, and produce huge amount of carbon dioxide (figure 3.) [3].

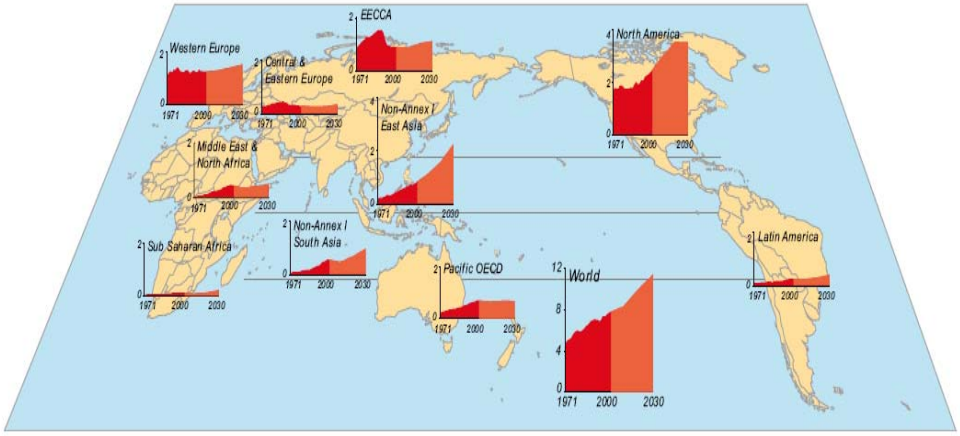

Figure 3. Emission of CO_2 (Gt) in buildings get by using of electric power [3]

Two thirds of energy has used for heating and cooling, mostly unnecessarily. Through the using of existing technology 90% of energy can be saved.
If energy efficiency can not be improved the consumption of energy and emission of CO_2 will be increased. According to McKinsey/Vattenfall till 2030.the quadrate of living spaces will be increased for 64% because of the world economy prosperity. It is important because living spaces have the highest percent in buildings.
In the area of Croatian energy efficiency, renewable energy sources and decreasing of greenhouse gases the following steps are taken:

- Program of Croatian energy efficiency from 2008. till 2016.
- The first national action plan for energy efficiency for period from 2008. till 2010.
- Scheme of Croatian strategy for energy development
- The low about energy efficiency – transfer of directive 2006/32/EZ
- Economical instruments like funds, state supports, project UNDP etc.

2. ENERGY EFFICIENCY

Energy efficiency is defined largely as cost-effective ways to reduce energy consumption through existing and improved technologies as well as through sound energy use practices. The idea behind energy efficiency is quite simple - if people consume less energy, there will be less emission of greenhouse gases as the result of the burning of fossil fuels. That, in turn, means a greater supply of fossil fuels which can then be used for other purposes in both developed and developing nations. Energy efficiency technologies and practices can therefore play a significant role in reducing the threat of global climate change. [4]
Energy efficiency is recognised as the most efficient and easy earning way to achieve goals of sustainable development through [5]:

- Decreasing of negative influence on environment that has produced by energetic sector [6],
- Decreasing of energy consumption and emission of carbon dioxide [7, 8, 9],
- Increasing of safe energy supply through the interruption of connections between economy development and energy requirements, and with increasing of competency of national economy [8, 10, 11, 12, 13].

To decrease energy spending and emission of gases and other elements engineers projected low energetic houses so called "Passive houses" [9], models of energy savings applicable for end users

[14], information systems [5,12,15,16,17,18,19,20], expert and intelligent systems [9,12,21] and fuzzy logic [22, 23, 24] for efficient energy managing and saving.
So, energy efficiency has to play key role in national energetic policy. Energy efficiency in buildings and sustainable construction, applying of renewable energy sources today become priority in energetic and construction area in European Union. Lack of energy and uncertainty of supplies, increasing of energy-generating product prices, climate changes and pollution, increasing of energy for cooling require serious approach in finding measures for energy efficiency, possibility in using of renewable energy sources, remote control in heating and cooling, decreasing of using of fossil and environment pollution.
Energy efficiency in buildings include the whole set of possibilities for thermo and electric energy savings, rationality in applying of fossil and renewable energy sources where that can be functionally done and economically sufficient.
Figure 4. [25] shows EU average on level of approximately 13 litres of oil that is used on square meter in one year. Through the applying of positive construction regulations spending can be decreased at 5 litres while passive houses can used only 2.2 litres.
For construction sector European commission brings three Directives for energy efficiency and environment protection:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (Official Journal L40/12of1989-02-11)
- Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency (SAVE) (Official Journal L 237 , 22/09/1993)
- Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings (Official Journal L 001,04/01/2003).

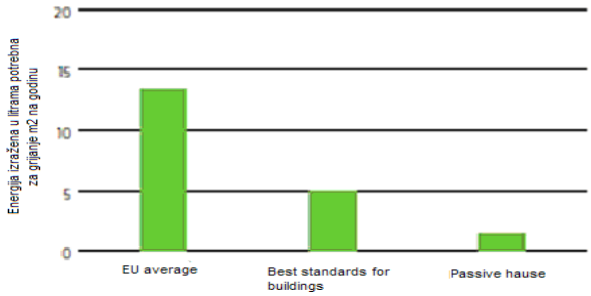

Figure4. Amount of oil energy necessary for heating of square meter per year [4]

Croatian legislation in the same areas brings :

- Law of energy [26]
- Law of funding for environment protection and energy efficiency [27]
- Law of construction [28]
- Technical rules about energy savings and thermo protection in buildings [29].

Through the building modernisation energy savings and decreasing of carbon dioxide can be realised. The technical solutions have to be feasible and economic.
Science and practical experiences show that equal decreasing of CO_2 can be amortised faster through the modernisation of modern and low temperature or condensation boilers than through the improvements of house thermo isolations.

3. INFORMATION TECHNOLOGY AND ENERGY EFFICIENCY

Republic of Croatia as signer of Kyoto protocol takes the obligation to decrease greenhouse gases for 20%, to increase part of renewable sources to 20% in overall spending of energy and energy efficiency.
To act on customer conscious is often problems in engineering practice especially how and in what way to save energy, which device saves energy and which not, and how much does it cost and what the time for return of investment is. Flow chart for making mentioned investment and technical analyses is given on figure 5
Table 1. shows attributes for thermal energy of 500 kW (devices and equipment for building with 10 to 15 flats). For each device is given two or three variants which are different according to scale of saving energy apropos overall investments. There are lots of questions like which equipment has to be chosen, how many energy will be saved, how much investment is, how long repayment period is and so on

Attribute: Energy-generating product

- Gas is used to activate boilers for heating and preparation of hot domestic water. Characterised by low price, great power efficiency and low emission of harmful gases
- Extra light distillate oil is used to activate boilers for heating and preparation hot domestic water. Characterised by easy transportation and possibility to be used where gas net is not fitted, great power efficiency and low emission of harmful gases
- Remote control heating from Thermal station which can be regular or cogeneration. Characterised by low losses, great power efficiency and low emission of harmful gases

Attribute: Boiler

- Steel or steel casting – low price, power efficiency till 85 %
- Low temperature is hardening steel – relatively low price, power efficiency from 90 till 95%, and longevity.
- Condensing: is steel which hardening by noble metals - power efficiency till 105 %

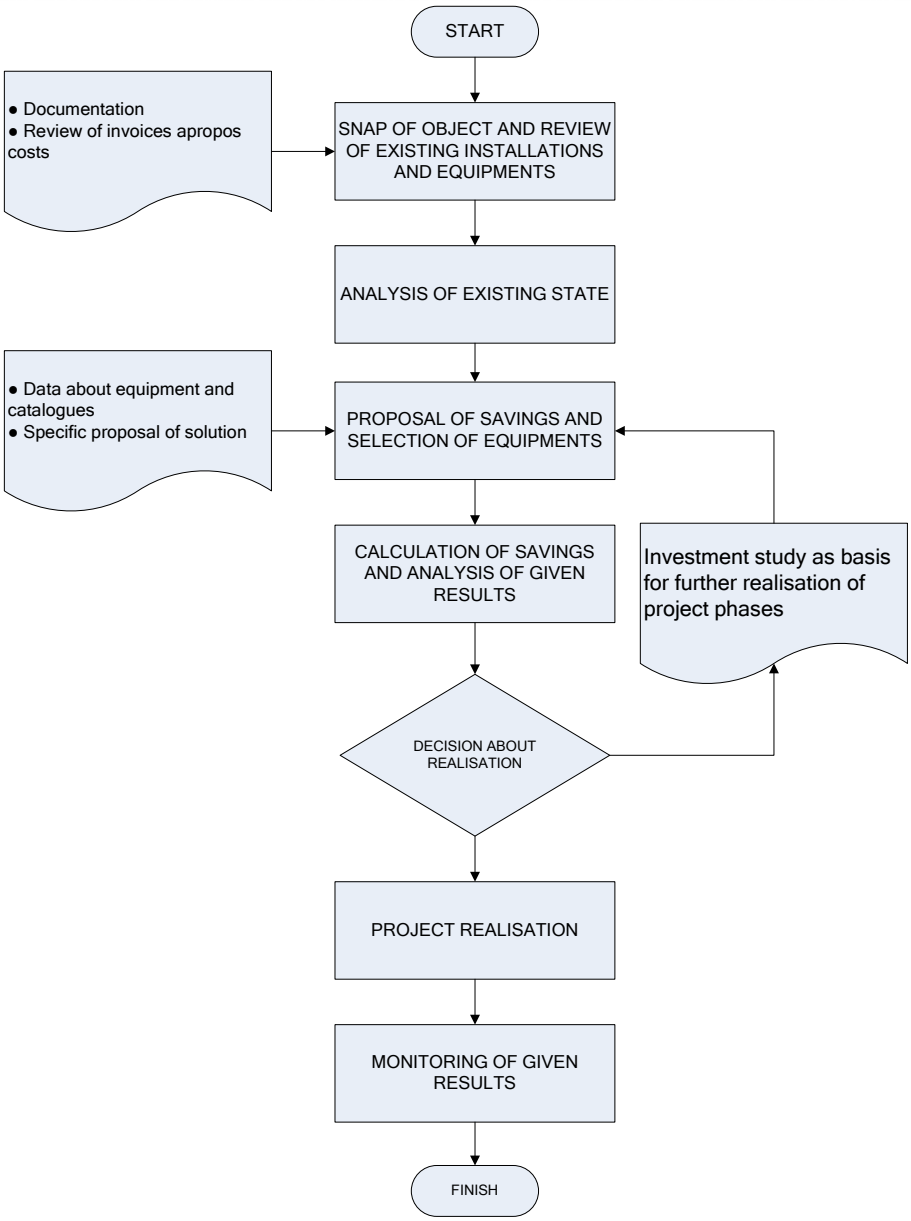

Figure5. Flow chart diagram

Attribute: Burner

- **Two-stage:** burner with two stages of work that depends on loading – characterised by simple assembly and spending of huge amount of energy-generating product
- **Modular**: flexible burner which power and loading depends on advance set curve.

Attribute: Regulation

- **Basic**: regulation that provides boiler and slave instruments, low price, low level of cost-effectiveness and efficiency
- **Lead by outside sensor**: regulation that uses outside temperature as input data for work
- **Cascade**: regulation that uses several parameters as inputs for work.

Attribute: Pump

- **Regular**: pump that works with the same power and amount of medium
- **Electronic**: pump with several velocities power that changes manually
- **Frequently**: pump that has frequent regulator. Great savings in savings energy for activation and energy which is carried by medium.

Table 1. Attributes

Attribute	Attribute values
Energy-generating product	Gas
	Extra light distillate oil
	District heating
Boiler	Steel
	Low temperature
	Condensing
Burner	Two-stage
	Modular
Regulation	Basic
	Lead by outside sensor
	Cascade
Pumps	Regular
	Electric
	Frequency
Balancing valves	Regular
	Manual balancing
	Three-way control valve
Thermal station	Without heat accumulation
	With heat accumulation
	For heating and preparation hot domestic water in flow
Pipeline	Steel
	Copper
	Plastic
Radiators	Laminated
	Ribbed
	Convector
Radiators valves	Ordinary
	Thermostatic
	Thermostatic with presetting
Building insulation	50 mm covering
	80 mm covering
	100 mm covering
Civil engineering characteristics (windows)	Wood joinery
	PVC
	ALU-PVC
Civil engineering characteristics (doors)	Wood joinery
	PVC
	ALU-PVC
Solar systems	For heating
	For preparation hot domestic water
	For heating and preparation hot domestic water
Thermal pumps	Water convection
	Air convection

Attribute: Balancing valves

- **Regular**: set in boiler room on start and reversible separators, low price, low energy savings
- **Manual balancing**: valves that have possibility to correct flow of medium and energy. It is possible to make hydraulic balancing of net.
- **Three-way control**: valves that have possibility of automatic flow and energy regulation through mixing. High savings through applying such valves.

Attribute: Thermal station

- **Without heat accumulation**: Compact heating station is device made for conducting and distribution heat from district heating net. It could be settled in small rooms in which are not possible to install heat accumulation tanks. Benefits are low price, relatively high energy savings, and long life cycle period.
- **With heat accumulation**: Compact heating station is device made for conducting and distribution heat from district heating net. Possibility to prepare hot domestic water with heat accumulation tanks. Benefits are low price, high energy savings, and long life cycle period.
- **For heating and preparation hot domestic water in flow**: Compact heating station is device made for conducting and distribution heat from district heating net. This station has possibility for heating and preparation of hot spending water in flow. Benefits are very high price, and very high energy savings.

Attribute: Pipeline – for flow of medium for heat transmission

- **Steel**: low price of material, relatively high price of incorporation
- **Copper**: high price of material, relatively low price of incorporation
- **Plastic**: restriction - only specific temperatures. Because of wall thickness they have insulation properties.

Attribute: Radiators – elements for heat delivery

- **Laminated**: relatively low price, short life cycle period, low level of utilisation
- **Ribbed**: relatively high price, medium level of utilisation
- **Convector**: possibility of fast raising of heat, relatively high price, high level of utilisation

Attribute: Radiators valves

- **Ordinary**: low price, without regulation
- **Thermostatic**: possible regulation, medium level of utilisation and cost-effectiveness
- **Thermostatic with presetting**: possibility of adjustment and calibration of valves, high price

Attribute: Building insulation

Increasing of covering thickness lead to rising of level of insulation capabilities (apropos amount of saved energy). Advantage of insulation is lower emission of greenhouse gases.

Attribute: Civil engineering characteristics (windows and doors):

Energy saving depends of material that is used for.

Attribute: Solar systems

- **For heating**: Systems that are using solar energy, for Zagreb Clime zone is more second source of heating than primary, save energy, expansive.
- **For preparation hot domestic water**: Systems that are using solar energy for preparing hot domestic water Benefits are low price, relatively high energy savings.

- **For heating and preparation hot domestic water**: Systems that are using solar energy, for Zagreb Clime zone is more second source of heating than primary, save energy especially when equipment for heating hot domestic water is added, expansive for installation.

Attribute: Thermal pumps

- **Water convection**: Systems that are subtracting energy from earth crust. With little help of another heating system it could be main source for heating. Benefits are extremely high price, high energy savings.
- **Air convection**: System could be combining with ventilation system which will implicate with higher saves according to investment.

To get answers on all questions it is necessary to pass possible combinations and variants. Binomial theorem (1) gives the overall number of combination

$$\binom{14}{1}\times 3+\binom{14}{2}\times 3^2+\binom{14}{3}\times 3^3+\binom{14}{4}\times 3^4+\ldots+\binom{14}{14}\times 3^{14} \qquad (1)$$

and that is 268.435.455,00 combinations

Thanks to that information the logical step was to make model of Information system which has to process data and to provide real reports. Reports have to be explicit and transparent and understandable to end user. Information system was developed and programmed in Microsoft Office Access 2003.

Figures 6. and 7. show reports after the selection of required data and necessary equipment.

Figure 6. Price of chosen equipment

Figure 7. Summary report

4. CONCLUSION

As is shown in Master plan of energy efficiency in Republic of Croatia housing division offers great opportunity for improving energetic efficiency and saving energy. The main problem is that customers do not know how to choose for efficiency energy measures and amount of spending energy. Information calculation is shown as very efficient instrument for customers informing about energy consumption and saving.
Sense of Informatics technology is get quick and proper information which will be base and start for thinking about energy saving. Energy saving implicate new way of thinking and conscience how to save energy, how to invest in devices and equipment that decrease losses in production, protection or conduction of energy.
Calculations that are realised through the reports could be fit in investment study and could be used as instruments in assuring financial aid and supporting in realisation of energy efficiency projects.

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