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## DEVELOPMENT OF SYSTEMS FOR MEASUREMENT AND CONTROL OF HOME AUTOMATION AND ELECTRIC ENERGY PARAMETERS USING THE „SMART HOUSES“ CONCEPT<sup>1</sup>

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**Abstract:** Construction Cluster DUNDJER from Nis, in partnership with the RDC Alfatec from Niš is working on development of systems for measurement and control of automatical domiciliary devices and electrical energy parameters using the “smart houses” concept. The electricity market in the Republic of Serbia includes two main actors: power distribution companies on the one hand and consumers on the other. It is in the mutual interest that consumed electric energy is properly registered. Electricity counters are with accuracy class 0.5 or worse. There are frequent cases where, because of their malfunction leads to incorrect registration of electric energy at the expense of the user or power distribution company. Frequent are also cut offs and higher supply voltage instability causing malfunctions in the devices and appliances of users.

Based on the above, there is need to develop a system that will have an accuracy class 0.5s and which, in addition to measuring the work, which includes software and hardware part contains a control unit which can work management software (industry) or electronics (household). Due to the different workforce equipment and devices, it is necessary to develop a line of products which includes different measuring ranges (measuring current transformers transmission ratio 75 / 5A, 40 / 5A and 5 / 5A) devices and specialized software package for the collection, analysis, graphic display and report generation. The software will be optimized for the computer and for ANDROID and IOS platform - view and control via tablet and mobile phone. This paper presents the main results of the project.

**Keywords:** Energy Efficiency, Electrical Energy Consumption, Measurement Systems, Control Systems, Smart house

## RAZVOJ SISTEMA ZA MERENJE, KONTROLU I UPRAVLJANJE KUĆNOM AUTOMATIKOM I PARAMETRIMA ELEKTRIČNE ENERGIJE PRIMENOM KONCEPTA “PAMETNE KUĆE”

**Резиме:** Грађевински кластер DUNDJER из Ниша, у партнерству са IRC Alfatec Ниш ради на развоју система за мерење, контролу и управљање кућном аутоматиком и параметрима електричне енергије применом концепта “паметне куће. Тржиште електричне енергије у Републици Србији подразумева два

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glavna aktera: elektrodistributivna preduzeća s jedne i potrošače sa druge strane. U obostranom interesu je da utrošena električna energije bude pravilno registrovana. Brojila električne energije imaju klasu tačnosti 0,5 ili lošiju. Česti su slučajevi kada, zbog njihove neispravnosti, dolazi do pogrešnog registrovanja utrošene električne energije na štetu korisnika ili elektrodistributivnog preduzeća. Česti su takođe i prekidi u napajanju kao i veće nestabilnosti mrežnog napona što prouzrokuje kvarove na uređajima i aparatima korisnika.

Na osnovu navedenog javlja se potreba za izradom sistema koji će imati klasu tačnosti 0,5s i koji, pored mernog dela koji podrazumeva softverski i hardveski deo, sadrži i kontrolnu jedinicu kojom je moguće upravljanje radom opreme (u industriji) ili električnim uređajima (u domaćinstvima). S obzirom na različitu radnu snagu opreme i uređaja, potrebno je razviti liniju proizvoda što podrazumeva različite merne opsege (strujne merne transformatore prenosnog odnosa 75/5A, 40/5A i 5/5A) uređaja kao i specijalizovani softverski paket za prikupljanje, analizu, grafički prikaz i izradu izveštaja. Softver će biti optimizovan za računar kao i za ANDROID i IOS platformu – prikaz i upravljanje preko tableta i mobilnih telefona. U ovom radu su prikazani glavni rezultati rada na projektu.

**Ključne reči:** Energetska efikasnost, potrošnja električne energije, merni sistemi, kontrolni sistemi, pametna kuća

## 1. PROJECT DESCRIPTION

Final energy consumption in the Republic of Serbia tends scenario with the implementation of energy efficiency measures. So, no matter what the economic development of the country, with the envisaged reindustrialization inevitably lead to increased demand for energy, it is necessary intensive implementation of measures and actions to increase energy efficiency to ensure that the indicators of energy intensity weight average values in the countries of the European Union.

Energy reconstruction in the building sector is one of the priority actions that define and regulate the current Law on the efficient use of energy.

Existing indicators of energy consumption in relation to GDP have value comparable with countries in the region, but significantly higher than average for EU countries.

Households in Serbia consume more than 2.5 times more energy per square meter of living space in comparison to northern countries of the EU.

In the area of građevinarstva evident determination to increase the energy efficiency of existing and especially new buildings. Great possibility of reducing the consumption of electricity is monitoring the consumption of electrical parameters and operation of electrical appliances. Establish mechanisms that will ensure

a permanent reduction of energy consumption in new buildings (new ways of designing and using new systems for control and power management) and proper reha-bilitation of existing buildings, the main goal of this project.

The electricity market in the Republic of Serbia includes two main actors: power distribution companies on the one hand and consumers on the other. In the mutual interest that consumed electric energy is properly registered. Electricity meters with accuracy class 0.5 or worse. There are frequent cases where, because of their malfunction leads to incorrect registration of electric energy at the expense of the user or power distribution company. Frequent are also cut offs and higher supply voltage instability causing malfunctions in the devices and appliances of users.

Based on the above, there is need to develop a system that will have an accuracy class 0.5s and which, in addition to measuring the work, which includes software and hardveski part contains a control unit which can work management software (industry) or electronics (household). Due to the different workforce equipment and devices, it is necessary to develop a line of products which includes different measuring ranges (measuring current transformers transmission ratio 75/5A, 40/5A and 5/5A) devices and specialized software package for the collection, analysis, graphic display and report generation. The software will be optimized for the computer and for ANDROID and

IOS plat-form-view and control via tablet and mobile phone.

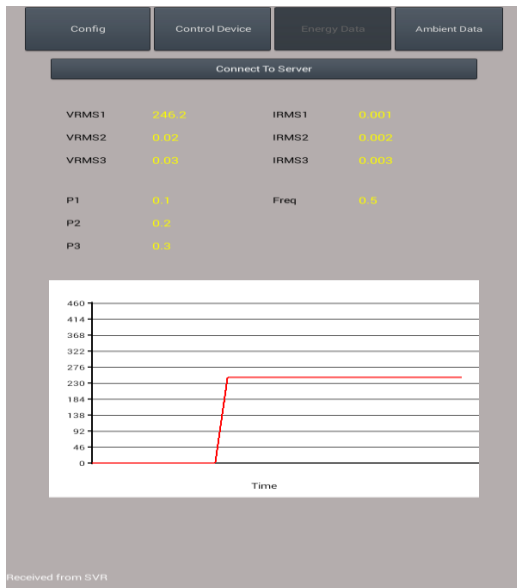


Figure 1. Diagrams of electrical paramteres shown in the smartphone display

The aforementioned new product should allow the preparation work of the power system to meet the requirements of the Law on the quality of electricity, whose adoption was announced in the near future.



Figure 2. One of possible solutions for using of MCM systems

2. END USERS OF THE PROJECT

There are clear needs of end users for this system. The primary beneficiaries will be designing and building organizations - SMEs which will be the main benefits:

- Planning the house will perform the implementation of this system through the design of new and reconstruction of existing buildings,
- The designers will go on training to operate this system as educated members of the cluster will be able to perform activities of providing consulting services in the field of use of the system and thus promote the project results,
- Installers software will go on training for installing and commissioning the system.

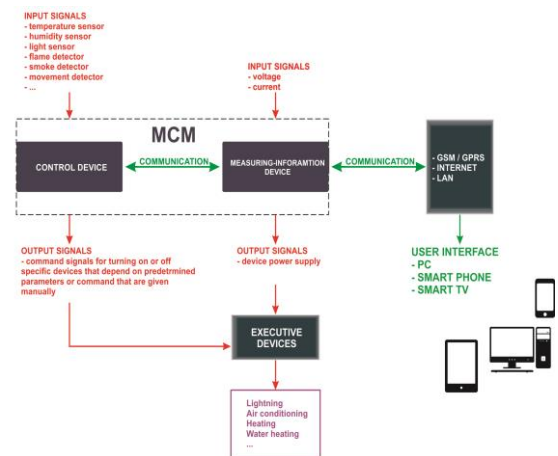
Investors, through the installation of such a system, increase the value of buildings and increase their final price, and thus their profits.

Property owners have a need to increase the reliability, register number and duration of interruptions and reduce bills for electricity consumed.

Electricity distribution companies have a need to increase the reliability of the power of consumers and to manage the total load (as shown by the program tasks of the future and has already implemented a large number of studies with the aforementioned themes).

Currently on the market of the Republic of Serbia there are systems that can be executed above requirements. Namely, in the implementation of the panel network analyzers foreign manufacturers whose price is high, have a lower accuracy class and therefore less accurate measurements and no ability to control.

Design and development of intelligent measurement and control system for power management, will solve those requirements and problems of the market, with a competitive price system.



*Figure 3. System's block diagram in the user's interface*

### 3. PROJECT ACTIVITIES

Within the project following activities are planned:

1. Analysis of the current situation and relevant standards

- Result: made SWOT analysis and marketing strategies. Obtained specific user requirements  
 - Indicators: their knowledge on competition, customer requirements, the potential fee, legal and professional framework and existing standards. Made study: Analysis of the development of multi-criteria analysis and evaluation of products

2. Design conceptual design to prototype MCM module

- Result: made preliminary design for the development of measuring and control unit shims  
 - Indicators: 3 projects for the development of product lines

3. Specification, selection and procurement of components and equipment for the production of prototypes and test models MCM module

- Score: Made with the technical documentation specified performance equipment as well as the type and characteristics of components for prototyping and pilot series system  
 - Indicators: a technical specification of the equipment and components and the study of the safety and environmental protection

4. Development of Prototypes and test series MCM module

- Score: Made prototypes and test series measuring and control module  
 - Indicators: - made one prototype version 3 modules as well as 10 pieces of test series for each of the three versions of the module

5. Definition of the algorithm and production software package for the collection, analysis, graphic display and control

- Score: Made software package

- Indicators: 1 software module for collecting, 1 software module for the analysis,  
 - 1 software module for graphic display and 1 software module for power management

6. Testing and functional test systems under laboratory conditions

- Result: a study is made of the results of tests  
 - Indicators: a study with 3 reports on executed measurements and calibration test series modules and 3 technical specifications and instructions for using the system

7. Measurement and alignment accuracy class and compatibility with standards LVD and EMC

- Score: The certificates and certificates of conformity  
 - Indicators: 1 certificate with the report on the class accuracy, 1 Potvreda and test report as evidence of product conformity to standards (C E character)

8. Testing the system in service conditions (residential and industrial buildings)

- As the result of: Made a report on the functional and technical characteristics of the system  
 - Indicators: 1 report on compliance with the requirements of system users and relevant power distribution companies with the specification of any malfunction, corrective and preventive measures

9. Training in the installation and use of the system

- Score: Made program and conducted user training  
 - Indicators: 16 participants trained in the installation and use of the system

10. Maintenance of the final conference and preparation of the final report

- Result: Executed promotion of new products and consortium  
 - Indicators: Made: internet portal, 500 pieces of product flyers, 500 pieces of flyers Consortium, promo film about the product and the consortium, the final report on the implementation of project activities

#### 4. IMPACT OF THE PROJECT ON OPENING NEW JOBS

The project has a direct impact on job creation and these are:

- Designers and installers measuring and control system, which will undergo adequate training for these jobs. The project envisages that a total of 16 participants passed the training, 6 engineers and 10 installers.
- There is a possibility of mass production measurement and control systems in existing or newly established companies, as well as the production of spare parts for maintenance services during warranty and post-warranty period as indirectly creates employment opportunities for a large number of qualified executors.

Of course, in order to better marketing performance and expanding markets in other regions and abroad, it is desirable to establish a network of partner organizations.

#### 5. INNOVATION PROJECT

The project is directly focused on innovation. The purpose of the project is to develop miniature electronic modules-measurement and information control unit for installation in low-voltage electrical installations with the necessary interfaces to the computer network, as well as adequate software support designed to monitor the parameters of electricity consumption. This system will be carried out and control of electrical appliances on the basis of given parameters consumption. It is primarily intended for households, residential and commercial buildings, small factories and other customers whose electricity consumption is relatively small and where the installation of complex systems to manage in real time would not be economically justified.

In this sense, the price of this product is reduced through the integration of measuring and information work in a microcontroller solution. The data collected in the measuring part are stored on a micro SD card, and downloading can be done by

replacing the card or through Ethernet port. The device must be equipped and optoizolovanim RS232 and RS485 communication channels through which it can be connected with other intelligent electronic devices in order to gather additional information from the environment, or with GSM/GPRS modems in order to connect to the remote centers in situations where this is not feasible via the Ethernet port, or when you want to backup communication channel. It is a new design solution as a result of years of product development and services in accordance with customer requirements and the use of positive experiences and applying best practices in the developed part of the world.

#### 6. PROJECT SUSTAINABILITY

Finding new target groups and community mobilization is possible to continue the project and its multiplication and extension to other fields of work and cooperation.

The interest of companies in the energy and construction sectors is that based on the results of this project form of innovative products in the field of equipment for energy-efficient buildings, recruit young researchers, hire additional staff in the product development process, and monitoring parameters during operation, thereby increasing their own competitiveness market and contribute to further sustainability and dissemination of project results.

Sustainability of the project is reflected in the aforementioned system upgrade options. The basic idea is increasingly becoming a reality in the home automation. The term "home automation" includes electrical small and medium-sized enterprises, which are not energy-intensive and the installation of miniature modules in low voltage installation can reduce power consumption control of a limited number of devices.

Over stations connected to the Internet can be programmed temperature, which will in the kitchen at breakfast time to be set to a single value, while the bathroom during morning shower automatically heat to the set temperature. Also living room could be heated to operating temperature after the end of working hours. With

a mobile phone or computer at work can be sent instructions for increasing temperature.

For heating can be the most to save. Special thermostats on radiators every room heated to the desired temperature-depending on weather conditions. Motion sensors in the rooms extinguish the light when there is no one there. Washing machine only works when electricity is cheap - the information she sends networked meter. The lighting changes as desired house-hold. All functions in the house can be programmed via the Internet or applications on the smartphone. When the tenants outside the housing unit, for example on holiday, motion sensors and burglary have the option of alert-ing you to danger. Sensors fire smoke alarm household in case of fire with the possibility of even a direct reference firefighters

## 7. PROJECT IMPACT ON LOCAL AND REGIONAL DEVELOPMENT

The impact of the project on local/regional development is reflected in:

- Increasing the energy efficiency of newly designed facilities and reconstruction of exist-ing buildings, commercial, and residential, installation of devices to monitor and control the consumption of electricity in the Nis region
- Generates the goal of raising public awareness about the need to save electricity.
- Contributes to increase the attractiveness of the building by customers because of high energy efficiency and savings on bills for electricity
- Installation of this measuring-control system makes a significant positive character-istic of the object to the issue of energy pass-port of the building;
  - step towards achieving the 20-20-20 Agenda;
  - It leads to an increase in final price of the property, considering all the above advantages.

Popularization of this approach to construction and reconstruction of buildings creates a precondition that in the near future are met requirements announced changes in legal regulations of the country that rely on EU Directive (introduction of "energy passport" in accordance with EU directive 2002/91/ EC), as and implementation of a 'clean development' as defined by

the Kyoto Protocol, which was ratified by the Republic of Serbia

## 8. PROJECT REPLICATION

The presence of intelligent energy management system in Serbia is almost non-existent. Systems that are present on the market use different technologies, different protocols and different equipment.

The general conclusion to be drawn after analyzing the needs and conditions prevailing in the market in relation to the product, service or technology that is the result of the project is that the domestic and international competition in the market is practically non-existent. Few systems that are offered are too expensive, closed to communication with other systems, and flexible enough to fit in a hierarchical higher-level systems such as power companies. Different data management systems are currently in use. All were developed and installed by different vendors, with each offering closed solution. The general standard for the format of data and database management is not applied. It is therefore necessary development of simple, secure and flexible communication infrastructure that allows monitoring, management, control and dispatching at all levels of energy management systems in households, small and medium enterprises, as well as the relationship with the relevant electric utility companies.

For these reasons it is concluded that the vast possibility of replicating the project and its effects on many sectors of the economy and all communities in the Republic of Serbia.

## 9. IMPACT OF THE PROJECT ON EXPORTS INCREASE/ NEW MARKETS

The project will greatly affect new markets because of the design company include the device in the design of new and reconstruction of old buildings, and thus increase their energy efficiency, which stand for contractors and subcontractors in foreign markets.

In addition, by the analysis of domestic and foreign markets, it was found that there are a number of potential beneficiaries in Serbia and the Western Balkan countries that are in technological terms at a very similar level. The results of the project will be far easier to qualify for the Western Balkan countries, and it is expected that at least part of these products will be able to find the application and in the markets of developed countries. A competitive market price, service network, support services and a sign of quality, are important factors that guarantee access to the new markets and boosting exports.

Potencional customers and users of this new product are primarily domestic, small and medium enterprises. More specifically, these are households with an average power consumption of about 1,000 kWh per year (which currently represents a market of about 400,000 consumers). Further, these are small and medium-sized enterprises with medium energy intensity (which currently represents a market of about 120,000 consumers).

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