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INTERNATIONAL FORUM FOR
CLEAN ENERGY TECHNOLOGIES

XIII MEĐUNARODNI FORUM O ČISTIM ENERGETSKIM TEHNOLOGIJAMA
XIII INTERNATIONAL FORUM FOR CLEAN ENERGY TECHNOLOGIES

ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE
ENERGY DIGITAL PERSPECTIVE OF SERBIA

ZBORNIK PROŠIRENIH APSTRAKATA
PROCEEDINGS OF THE EXTENDED ABSTRACTS

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Poštovane dame i gospodo, dragi prijatelji,

Nalazimo se u trinaestoj godini rada Međunarodnog foruma o čistim energetskim tehnologijama (Forum), koji će se ove godine održati 29-30. oktobra pod nazivom „ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE“. Nakon tri godine dodele priznanja „TOP ENERGY“ za najuspešnije izvedene projekte u oblasti energetike u Srbiji i Jugoistočnoj Evropi, obavezni smo da i ove godine istaknemo najbolje digitalno integrisane i realizovane projekte i omogućimo postizanje višeg kvaliteta događaja i širi obuhvat njegovog programskog koncepta.

Duži period Republika Srbija ulaže posebne napore u procesu unapređenja sopstvene energetske bezbednosti i izgradnje infrastruktura, koje treba da zadovolje rastuće potrebe za energijom. Gotovo identični procesi se dešavaju i u zemljama regiona Jugoistočne Evrope, potvrđujući još jednom činjenicu da niko na ovom prostoru ne može dozvoliti svoju pasivnost, niti da postane izolovano energetsko ostrvo. Otvaranje procesa opšte nacionalne digitalizacije u Republici Srbiji, nameće nam obavezu da osloncem na domaće i regionalne projekte, kao i kroz sinergiju dugoročnih zajedničkih interesa u postizanju energetske bezbednosti kao osnove održivog razvoja, stavimo u prvi plan ostvarenje najvažnijeg principa održivog razvoja – energija i digitalizacija za sve!

Opredeljenje Programskog odbora XIII Foruma, da se u trinaestoj godini njegovog postojanja i delovanja pod pokroviteljstvom Skupštine Autonomne pokrajine Vojvodine i sa koorganizatorima Pokrajinskim sekretarijatom za energetiku, građevinarstvo i saobraćaj i Privrednom komorom Vojvodine, ovogodišnji fokus Republike Srbije i zemalja regiona ispolji na što je moguće primenjivijoj identifikaciji konkretnih procesa i projekata i njihovog energetskog unapređenja kroz primenu novih digitalnih tehnologija i rešenja, kao načinom za postizanje postavljenih zajedničkih evropskih ciljeva. Do sada smo dograđivali planove energetskog razvoja na horizontu do 2020. godine, koja je već pred nama, a sada ćemo pokušati da stavimo sopstvene potencijale u kontekst predviđanja strateških ciljeva do 2050. godine. EU energetska mapa puta 2050, nudi vrlo inovativan pristup u postizanju konačnih ciljeva i pogled iz budućnosti u sadašnjost, sa namerom da se sagledaju potrebe promena ekonomskog i društvenog sistema koje će nas odvesti do željenih ciljeva. Takav pristup zahteva vrlo dinamične i fleksibilne energetske politike, kao i druge politike spregnute sa njom, svih onih koji žele da pripadaju korpusu uspešnih nacija budućnosti, ali i posebno dobro kontrolisane mehanizme nadzora realizacije tih politika. Digitalizacija danas omogućuje promenu procedure realizacije svih politika i ostvarivanje njihovog pouzdanog i efikasnog nadzora. Sve su to preduslovi dinamičke promene politika i stvaranje novog kvaliteta koji se ogleda u stalnim promenama i prilagođavanjima okruženju.

Naša je zajednička vizija da ovogodišnji dvodnevni rad Foruma, kredibilitetom budućih prezentovanih koncepata, tehnoloških rešenja i naučnih radova, treba da podstakne kreativnije i konkretnije korišćenje raspoloživih potencijala u čistoj energiji na ovim prostorima, dodatno pokrene saradnju i razvoj energetike i digitalizacije u zemljama regiona i usmeravanje naše budućnosti ka visokim ciljevima EU energetske mape puta 2050.

Prvi dan Foruma biće, pored plenarne sednice na kojoj će se obratiti najviši zvaničnici države domaćina i ugledni gosti iz inostranstva, posvećen razmatranju i aktuelizaciji potrebnih aktivnosti u procesu ostvarivanja usvojene energetske strategije pod nazivom „ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE“, kao i postignutih rezultata u odnosu na postavljene ciljeve energetske politike, nacionalne digitalizacije i održivog razvoja Republike Srbije, kao i najave velikih nacionalnih projekta koji će nas kvalifikovati za bolju i pametniju budućnost.

Sastavni deo treće i četvrte industrijske revolucije, koju živimo, su pametni gradovi i digitalne infrastrukture. Međutim, transformacija i digitalizacija gradova je vrlo spora jer je proces promena vrlo složen, a najveća prepreka su ljudi koji su po prirodi stvari nespremni za promene. Pozitivne promene u nekim velikim gradovima daju za pravo verovanju da su takve pozitivne promene moguće i ekonomski opravdane i da je moguće gradove i zgrade posmatrati, ne kao potrošače energije, već i kao proizvođače. Na primeru projekata u realizaciji jedne od 100 najuspešnijih svetskih kompanija na *World Finance List*-i DANA HOLDINGS Company, biće predstavljeni evroazijski mega projekti, koji u sebi sadrže sve elemente najnovijih digitalnih tehnoloških dostignuća i ispunjavaju sve kriterijume koje zahtevaju pametni gradovi. U tom projektu i prezentaciji čiji je koautor kompanija BK TESLA d.o.o. Srbija, kao partneri učestvuju i najpoznatije svetske kompanije.

Takođe, prilikom svečanog otvaranja Foruma biće dodeljena priznanja „TOP ENERGY 2019“, za najuspešnije realizovane projekte iz oblasti energetike u Srbiji i zemljama Jugoistočne Evrope u protekloj godini. Istovremeno, biće sagledana iskustva zemalja regiona i EU, kroz učešće referentnih predstavnika država učesnica i evropskih regija i prezentacijama radova po pozivu, na teme „NOVE DIGITALNE ENERGETSKE TEHNOLOGIJE“ i „UPRAVLJANJE PAMETNIM URBANIM SISTEMIMA I DIGITALNIM INFRASTRUKTURAMA“. U svim radnim sesijama, nakon prezentacija, biće otvorene panel diskusije, koje u konačnom zajedničkom zaključku treba da ponude jasne poruke o mogućem dinamičnijem održivom razvoju digitalizovanog energetskog sektora u Srbiji i regionu do 2050. godine.

Drugi dan Foruma, uz kopokroviteljstvo Privredne komore Vojvodine, posebno će biti usmeren na razmatranje ostvarenih poslovnih projekata iz zemlje i inostranstva, kroz tematske sesije „REALIZOVANI PROJEKTI U OBLASTI ENERGETSKE I DIGITALNE INTEGRACIJE, OBNOVLJIVIH IZVORA ENERGIJE I UPRAVLJANJA ENERGIJOM“ i „DOMAĆE I MEĐUNARODNO PARTNERSTVO – PREDSTAVLJANJE NOVIH TEHNOLOGIJA I MOGUĆNOSTI SARADNJE“.

Pozivamo Vas, da učestvujete na ovogodišnjem XIII Forumu „ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE“ i date svoj doprinos u kreiranju vizije digitalne energetske budućnosti, kao i realizaciji poslovnih projekata i jačanju međusobnih odnosa i energetske bezbednosti Republike Srbije i zemalja Jugoistočne Evrope

S poštovanjem,

Dr Tihomir Simić Predsedavajući Foruma	Ivo Vajgl Kopredsedavajući Foruma

Jun, 2019. godine

Dear ladies and gentlemen and dear friends,

We are in the thirteenth year of work of the International Forum on Clean Energy Technologies (Forum) that will be held on 29th and 30th October this year under the name “ENERGY DIGITAL PERSPECTIVE OF SERBIA”. After three years of the “TOP ENERGY” awards for the most successfully implemented projects in the field of energy in Serbia and in the Southeast Europe, we are obliged to emphasize the best digitally integrated and realized projects this year and to make possible the high quality event with the program concept of a wider scope.

For quite some time, the Republic of Serbia has been making special efforts in the process of improving its energy security and in the construction of infrastructure which should meet the growing energy demand. Almost identical processes are taking place in other countries in the region of the Southeast Europe thus, confirming once again, that no one in this area can allow to be passive or to become an isolated energy island. The opening of the process of general national digitization in the Republic of Serbia imposes the obligation to rely on domestic and regional projects and, through synergy of long term common interests in achieving energy security as the basis of sustainable development, to put in the forefront the implementation of the most important principle of sustainable development - energy and digitization for all!

The decision of the Program Committee of the Thirteenth Forum is that in the thirteenth year of the Forum’s existence and work under the auspices of the Assembly of the Autonomous Province of Vojvodina and co-organizers, the Provincial Secretariat for Energy, Construction and Transport and the Chamber of Economy of Vojvodina, the focus of the Republic of Serbia and the countries of the region will be put on the most applicable identification of concrete processes and projects and their energy improvement through the use of new digital technologies and solutions, as a way to achieve the preset common European objectives. So far, we have been upgrading energy development plans on the horizon up to 2020, which is already ahead of us and now, we will try to put our own potentials in the context of forecasting strategic objectives up to 2050. The EU Energy Roadmap 2050 offers a very innovative approach to achieving ultimate objectives and a look from the future into the present, in order to consider the needs of changing the economic and social system that will take us to the desired objectives. Such an approach requires not only very dynamic and flexible energy policies and other policies connected with them of all those who want to belong to the group of successful nations of the future, but also especially well-controlled mechanisms for monitoring the implementation of these policies. Today, digitalization enables the change of the procedure for the implementation of all policies and the achievement of their reliable and efficient supervision. These are all prerequisites for the dynamic change of policies and for the creation of a new quality that is reflected in constant changes and adjustments of the surroundings.

Our common vision is that this year's two day work of the Forum should encourage more creative and concrete use of available potentials in clean energy in this region, initiate further cooperation and development of the energy sector and digitalization in the countries of the region and focus our future towards high objectives of the EU Energy Roadmap 2050 by means of the credibility of presented concepts, technological solutions and scientific papers.

In addition to the plenary session at which high officials of the host country and distinguished guests from abroad will address those who are present, the first day of the Forum will be devoted to the consideration and actualization of activities that are necessary in the process of the implementation of adopted energy strategy entitled “ENERGY DIGITAL PERSPECTIVE OF SERBIA”, as well as to results achieved in relation to preset objectives of the energy policy, national digitalization and sustainable development of the Republic of Serbia and to the announcement of major national projects that will qualify us for a better and smarter future.

Smart cities and digital infrastructures make an integral part of the third and fourth industrial revolution in which we live. However, the transformation and digitalization of cities is very slow because the process of change is very complex and the biggest obstacle is people who are by their nature unprepared for changes. Positive changes in some big cities give us the right to believe that such positive changes are possible and economically justified and that it is also possible to observe cities and buildings not only as energy consumers, but also as energy producers. On the example of projects that are undertaken by one of the 100 most successful global companies on the *World Finance List*, DANA HOLDINGS Company, Euro-Asian mega projects will be presented that contain all the elements of the most recent digital technological achievements and that meet all the criteria required by smart cities. The most famous world companies are included as partners in this project and presentation whose co-author is the BK TESLA Company LLC, Serbia.

Also, during the opening ceremony of the Forum, “TOP ENERGY 2019” awards will be given for the most successful projects implemented in the energy sector in Serbia and in the countries of Southeast Europe in the previous year. At the same time, the experiences of the countries in the region and in the EU will be discussed through the participation of relevant representatives of participating countries and the European regions and through the presentation of papers by invited authors on the topics of “NEW DIGITAL ENERGY TECHNOLOGIES” and “MANAGEMENT OF SMART URBAN SYSTEMS AND DIGITAL INFRASTRUCTURE”. In all working sessions, panel discussions will be opened after presentations and in the final common conclusion they should provide clear messages about the possible more dynamic sustainable development of the digitalized energy sector in Serbia and the region by 2050.

The second day of the Forum under the co-auspices of the Chamber of Economy of Vojvodina will be especially focused on the review of implemented business projects in the country and abroad through thematic sessions “PROJECTS IMPLEMENTED IN THE FIELD OF ENERGY EFFICIENCY AND DIGITAL INTEGRATION, RENEWABLE ENERGY SOURCES AND ENERGY MANAGEMENT” and “DOMESTIC AND INTERNATIONAL PARTNERSHIP – PRESENTATION OF NEW TECHNOLOGIES AND OPPORTUNITIES FOR COOPERATION”.

We take this opportunity to invite you to participate at this year's Thirteenth Forum “ENERGY DIGITAL PERSPECTIVE OF SERBIA” and to give your contribution in creating the vision of the digital energy future, as well as, in implementing business projects and strengthening mutual relations and energy security of the Republic of Serbia and of the countries in the Southeast Europe.

Respectfully Yours,

Tihomir Simić, D. Sc.
Chairman of the Forum

Ivo Vajgl
Co-Chairman of the Forum

June, 2019

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Prvi dan (utorak, 29. oktobar 2019. godine)
Kongresni centar Master Novosadskog sajma
Hajduk Veljkova 11, 21000 Novi Sad

	PLENARNA SESIJA – „ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE"
8:30 – 9:30	**Registracija učesnika**
9:30 – 10:30	**Svečano otvaranje XIII Foruma ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE**
	Uvodna reč – *Tihomir Simić*; *Predsedavajući Foruma, Novi Sad, Srbija*
	Pozdravna obraćanja
	Ivo Vajgl*; Predsednik za Jugoistočnu Evropu INEA – Institut za evropske poslove, Diseldorf, Nemačka*
	Nenad Grbić*; Pokrajinski sekretar za energetiku, građevinarstvo i saobraćaj, Novi Sad, Srbija*
	Milan Radovanović*; Predsednik Društva termičara Srbije, Beograd, Srbija*
	Dejan Popović*;Predsednik Saveta Agencije za energetiku Republike Srbije, Beograd, Srbija*
	Rade Doroslovački*; Dekan Fakulteta tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
	Ištvan Pastor*; Predsednik Skupštine Autonomne pokrajine Vojvodine, Novi Sad, Srbija*
	Aleksandar Antić*; Ministar rudarstva i energetike Republike Srbije, Beograd, Srbija*
	Ana Brnabić*; Predsednik Vlade Republike Srbije, Beograd, Srbija (očekuje se potvrda)*
	Svečana dodela priznanja „TOP ENERGY" i svečano otvaranje Foruma
	Zajednička fotografija
	Konferencija za medije
10:30 – 11:00	**Pauza za kafu**
	PRVA RADNA SESIJA **ENERGETSKE STRATEGIJE**
11:00 – 13:20	**DIGITALNA OSNOVA BUDUĆNOSTI**
	Tihomir Simić*; Predsedavajući Foruma o čistim energetskim tehnologijama, Novi Sad, Srbija*
	EVROPSKI ENERGETSKI CILJEVI DO 2050. GODINE – ENERGETSKI IZAZOV SRBIJE
	Miloš Banjac*; Ministarstvo rudarstva i energetike u Vladi Republike Srbije, Beograd, Srbija*
	ODRŽIVI RAZVOJ ENERGETIKE REPUBLIKE SRBIJE – REGULATIVA I PERSPEKTIVE
	Aca Marković*; Agencija za energetiku Republike Srbije, Beograd, Srbija*
	ATLAS ENERGETSKE EFIKASNOSTI JAVNIH ZGRADA AUTONOMNE POKRAJINE VOJVODINE
	Slavoljub Arsenijević*; Pokrajinski sekretarijat za energetiku, građevinarstvo i saobraćaj, Novi Sad, Srbija*
	ENERGETSKA EFIKASNOST I DIGITALNE TEHNOLOGIJE
	Dušan Gvozdenac, Branka Gvozdenac Urošević*; Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
	VETROPARK KOVAČICA – PREZENTACIJA PROJEKTA
	Miloš Colić*; New Energy Solutions, Beograd, Srbija*
	Panel diskusija
13.20 – 13.30	**Pauza za kafu**
	DRUGA RADNA SESIJA **ENERGIJA I DIGITALIZACIJA ZA PAMETNU BUDUĆNOST**
13:30 – 15:40	**ATLAS – PRVI DIGITALNI MIKROPROCESORSKI TELEINFORMACIONI SISTEM**
	Božidar Levi*; Institut Mihajlo Pupin, IMP-Automatika doo, Beograd, Srbija*
	SAVREMENI PRISTUPI ENERGETSKOG RAZVOJA U ZGRADARSTVU
	Miroslav Kljajić*, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
	SMART CITY – MINSK WORLD
	Tihomir Simić, Vibor Mulić*; BK DANA Holdings Group, Minsk, Belorusija*
	OSETI SVOJ SVET (SA IoT REŠENJIMA); *SENSE YOUR WORLD (WITH IoT SOLUTIONS)*
	Milutin Cvetković; *SAGA doo, Beograd, Srbija*
	DIGITALNI POTPIS – SMART CITY U PRAKSI; *DIGITAL SIGNAGE - SMART CITY IN PRACTICE*
	Daniel Golić*; SAGA doo, Beograd, Srbija*
	TRANZICIJA U ODRŽIVE I PAMETNE SISTEME DALJINSKOG GREJANJA – PRIMER GRADA BANJA LUKA
	Dejan Jovišević*; EKO TOPLANE Banja Luka, Republika Srpska, BiH*
	FNIZ (FOTONAPONSKI INTEGRISANE ZGRADE) PUTEM PAMETNE MREŽE, TOPLOTNIM PUMPAMA TOPLOTNA UPOTREBA PODZEMLJA I NAPUŠTENIM RUDNICIMA SKLADIŠTENJE ENERGIJE ZA KORIŠĆENJE OIE VELIKIH RAZMERA
	Marija Todorović*; Southeast University, Nanjing, Kina, CEO vea-invi.ltd, Beograd, Srbija*
	Panel diskusija
15:45	**Koktel**

Drugi dan (sreda, 30. oktobar 2019. godine)
Velika sala, Privredna komora Vojvodine
Hajduk Veljkova 11, 21000 Novi Sad

	TREĆA RADNA SESIJA **REALIZOVANI PROJEKTI U OBLASTI DIGITALNIH ENERGETSKIH INTEGRACIJA, ENERGETSKE EFIKASNOSTI, OBNOVLJIVIH IZVORA ENERGIJE I UPRAVLJANJA ENERGIJOM**
8:30 – 9:00	**Registracija učesnika**
9:00 – 9:05	**OBRAĆANJE PREDSEDAVAJUĆEG FORUMA** ***Tihomir Simić;*** *Predsedavajući Foruma, Novi Sad, Srbija*
9:05 – 9:10	**POZDRAVNA REČ** ***Boško Vučurević;*** *Predsednik Privredne komore Vojvodine, Novi Sad, Srbija*
9:10 – 9:25	**UNDP/GEF PROJEKAT UKLANJANJE PREPREKA ZA PROMOVISANJE I PODRŠKU SISTEMU ENERGETSKOG MENADŽMENTA U OPŠTINAMA U SRBIJI** ***Maja Matejić, Dragan Urošević****; UNDP, Beograd, Srbija*
9:25 – 9:40	**KULTUROLOŠKI FAKTORI PONAŠANJA KRANJIH POTROŠAČA ENERGIJE I KONKURENTNOST** ***Valentina Ivanić****; Cultural Due Diligence Institute, Novi Sad, Srbija*
9:40 – 9:55	**ANALIZA SLOŽENIH ENERGETSKIH SISTEMA UPOTREBOM VEŠTAČKIH NEURONSKIH MREŽA** ***Branka Gvozdenac Urošević, Damir Đozić;*** *Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
9:55 – 10:10	**BIOEKONOMIJA – NOVI KONCEPT PRIVREDNOG RAZVOJA SA ZNAČAJNIM UTICAJEM NA BUDUĆE ENERGETSKE POLITIKE** ***Goran Vasić;*** *Garancijski fond AP Vojvodine, Novi Sad, Srbija*
10:10 – 10:25	**UTICAJ PRIMENE TOPLOTNIH PUMPI NA POTROŠNJU PRIMARNE ENERGIJE U SRPSKIM ŠKOLAMA** ***Mirko Stojiljković*, Dušan Ranđelović**, Marko Ignjatović*, Goran Vučković****; * Univerzitet u Nišu, Mašinski fakultet u Nišu, Niš, Srbija** Univerzitet u Nišu, Građevinsko-arhitektonski fakultet u Nišu, Niš, Srbija*
10:25 – 10:35	**Pauza za kafu**
10:35 – 10:50	**PRETNJE I TIPSKA REŠENJA BEZBEDNIH INDUSTRIJSKIH OT MREŽA** ***Slavko Dubačkić, Aleksandar Bošković, Đorđe Vladisavljević;*** *CIT, ODS „EPS Distribucija", Beograd, Srbija; Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija; CIT, ODS „EPS Distribucija", Beograd, Srbija*
10:50 – 11:05	**PREDNOSTI UPOTREBE TOPLOTNE PUMPE U KOMORNOJ SUŠARI ZA PEČURKE** ***Nikola Milivojević, Damir Đaković;*** *Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
11:05 – 11:20	**PREGLED I PREPORUKE RASPOLOŽIVIH TEHNOLOGIJA ZA IMPLEMENTACIJU TELEKOMUNIKACIONOG PODSISTEMA KAO DELA SISTEMA AUTOMATIZACIJE DISTRIBUCIJE** ***Đorđe Vladisavljević, Slavko Dubačkić, Aleksandar Bošković;*** *CIT, ODS „EPS Distribucija", Beograd, Srbija; Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*
11:20 – 11:35	**ISKUSTVA U PRIMENI SOLARNE ENERGIJE** ***Miodrag Vuković****; Conseko, Beograd, Srbija*
11:35 – 11:50	**IZRADA AKCIONOG PLANA ZA PODSTICANJE POVEĆANJA KORIŠĆENJA OBNOVLJIVIH IZVORA ENERGIJE NA TERITORIJI OPŠTINE BAČKA PALANKA** ***Zoltan Zavargo****; ENEF Klaster, Novi Sad, Srbija*
11:50 – 12:00	**Pauza za kafu**
	ČETVRTA RADNA SESIJA **u organizaciji Društva za KGH Srbije pri SMEITS** **RASHLADNA TEHNIKA – TRENDOVI, ISKUSTVA, PRIMENA**
12:00 – 12:15	**REGULATIVA U OBLASTI RASHLADNE TEHNIKE** ***Slobodan Pejković****; Društvo za KGH Srbije pri SMEITS, Beograd, Srbija*
12:15 – 12:30	**SPECIFIČNOSTI PRIMENE I TEHNIČKA REŠENJA ZA PRIRODNA RASHLADNA SREDSTVA** ***Vladimir Sovilj****; Frigoria, Novi Sad, Srbija*
12:30 – 12:45	**PRIRODNA RASHLADNA SREDSTVA – ISKUSTVA U PRIMENI** ***Vladimir Beljanski,*** *Danfoss, Srbija*
12:45 – 13:00	**PRIMENA INDUSTRIJSKIH AMONIJAČNIH TOPLOTNIH PUMPI U PROIZVODNJI SLADA** ***Dragutin Miljković, Nebojša Pejić, Zoran Stajić;*** *Tehnomag-Teco, Novi Sad, Soufflet Srbija, Bačka Palanka, Emerson Commercial & Residental Solutions-Vilter, Beograd, Srbija*
13:00 – 13:40	**Diskusija; Zaključci; Aktuelne informacije**
	ZATVARANJE XIII FORUMA
13:40 – 14:00	**Predlog zaključaka XIII Foruma i svečano zatvaranje skupa** ***Tihomir Simić;*** *Predsedavajući Foruma o čistim energetskim tehnologijama, Novi Sad, Srbija*
14:00	**Koktel**

First Day (Tuesday, October 29, 2019)
Congress Center Master of the Novi Sad Fair
11, Hajduk Veljkova Street, 21000 Novi Sad

	PLENARY SESSION – "SERBIAN DIGITAL ENERGY PERSPECTIVE"
8:30 – 9:30	**Registration of participants**
9:30 – 10:30	**Ceremonial opening of the XIII Forum SERBIAN DIGITAL ENERGY PERSPECTIVE**
	Introductory speech – ***Tihomir Simić****; Chairman of the Forum, Novi Sad, Serbia*
	Welcome speeches
	Ivo Vajgl*; President for the Southeast Europe of INEA* **-** *Institute for European Affairs, Dusseldorf, Germany and Member of the European Parliament, Brussel, Belgium*
	Nenad Grbić*; Provincial Secretary for Energy, Construction and Traffic, Novi Sad, Serbia*
	Milan Radovanović*; President of the Society of Thermal Engineers of Serbia, Belgrade, Serbia*
	Dejan Popović*; President of the Council of the Energy Agency of the Republic of Serbia, Belgrade, Serbia*
	Rade Doroslovački*; Dean of the Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
	Ištvan Pastor*; President of the Assembly of the Autonomous Province of Vojvodina, Novi Sad, Serbia*
	Aleksandar Antić*; Minister of Mining and Energy of the Republic of Serbia, Belgrade, Serbia*
	Ana Brnabić*; Prime Minister of the Serbian Government, Belgrade, Serbia (to be confirmed)*
	"TOP ENERGY" award ceremony and official opening of the Forum
	Joint photograph
	Press conference
10:30 – 11:00	**Coffee break**
	FIRST WORKING SESSION **ENERGY STRATEGIES**
11:00 – 13:20	**DIGITAL BASIS OF THE FUTURE**
	Tihomir Simić*; President of the Forum for Clean Energy Technologies, Novi Sad, Serbia*
	EUROPEAN 2050 ENERGY TARGETS – ENERGY CHALLENGE FOR SERBIA
	Miloš Banjac*; Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia*
	SUSTAINABLE DEVELOPMENT OF THE ENERGY SECTOR IN THE REPUBLIC OF SERBIA – REGULATIONS AND PERSPECTIVES
	Aca Marković*; Energy Agency of the Republic of Serbia, Belgrade, Serbia*
	ATLAS OF PROVINCIAL BUILDINGS ENERGY EFFICIENCY
	Slavoljub Arsenijević*; Provincial Secretariat for Energy, Construction and Traffic, Novi Sad, Serbia*
	ENERGY EFFICIENCY AND DIGITAL TECHNOLOGIES
	Dušan Gvozdenac, Branka Gvozdenac Urošević*; Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
	WIND FARM KOVAČICA – PRESENTATION OF THE PROJECT
	Miloš Colić*; New Energy Solutions, Belgrade, Serbia*
	Panel discussion
13.20 – 13.30	**Coffee break**
	SECOND WORKING SESSION **ENERGY AND DIGITALIZATION FOR SMART FUTURE**
13:30 – 15:40	**ATLAS – THE FIRST DIGITAL MICROPROCESSOR TELE-INFORMATION SYSTEM**
	Božidar Levi*; Institute Mihailo Pupin, IMP Automation & Control Systems Ltd, Belgrade, Serbia*
	MODERN APPROACH TO ENERGY DEVELOPMENT IN THE BUILDING SECTOR
	Miroslav Kljajić*, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
	SMART CITY – MINSK WORLD
	Tihomir Simić, Vibor Mulić*; BK DANA Holdings Group, Minsk, Belarus*
	SENSE YOUR WORLD (WITH IOT SOLUTIONS)
	Milutin Cvetković; *SAGA Ltd, Belgrade, Serbia*
	DIGITAL SIGNAGE - SMART CITY IN PRACTICE
	Daniel Golić*; SAGA Ltd, Belgrade, Serbia*
	TRANSITION TO SUSTAINABLE AND SMART DISTRICT HEATING SYSTEMS – EXAMPLE OF CITY OF BANJA LUKA
	Dejan Jovišević*; EKO TOPLANE, Banja Luka, Republika Srpska, BiH*
	BIPV (BUILDING-INTEGRATED PHOTOVOLTAIC) VIA SMART GRID, HEAT PUMPS THERMAL USE OF UNDERGROUND AND ABANDONED MINES ENERGY STORAGE FOR LARGE-SCALE RES UTILISATION
	Marija S. Todorović*; Southeast University, Nanjing, China, CEO vea-invi.ltd, Beograd, Serbia*
	Panel discussion
15:45	**Cocktail**

Second Day (Wednesday, October 30, 2019)
Main Hall, Chamber of Economy of Vojvodina
11, Hajduk Veljkova Street, 21000 Novi Sad

THIRD WORKING SESSION
PROJECTS IMPLEMENTED IN THE FIELD OF DIGITAL ENERGY INTEGRATIONS, ENERGY EFFICIENCY, RENEWABLE ENERGY SOURCES AND ENERGY MANAGEMENT

8:30 – 9:00	**Registration of participants**
9:00 – 9:05	**INTRODUCTORY SPEECH** ***Tihomir Simić;*** *Chairman of the Forum, Novi Sad, Serbia*
9:05 – 9:10	**WELCOME SPEECH** ***Boško Vučurević;*** *President of the Chamber of Economy of Vojvodina, Novi Sad, Serbia*
9:10 – 9:25	**UNDP/GEF PROJECT FOR REMOVING BARRIERS TO PROMOTE AND SUPPORT THE ENERGY MANAGEMENT SYSTEM IN MUNICIPALITIES IN SERBIA** ***Maja Matejić, Dragan Urošević****; UNDP, Belgrade, Serbia*
9:25 – 9:40	**CULTURAL FACTORS OF BEHAVIOR OF END ENERGY USERS AND COMPETITIVENESS** ***Valentina Ivanić****; Cultural Due Diligence Institute, Novi Sad, Serbia*
9:40 – 9:55	**ANALYSIS OF COMPLEX ENERGY SYSTEMS BY MEANS OF ARTIFICIAL NEURAL NETWORKS** ***Branka Gvozdenac Urošević, Damir Đozić;*** *Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
9:55 – 10:10	**BIO-ECONOMY – A NEW CONCEPT OF ECONOMIC DEVELOPMENT SIGNIFICANTLY AFFECTING FUTURE ENERGY POLICY** ***Goran Vasić;*** *Guarantee Fund of the Autonomous Province of Vojvodina, Novi Sad, Serbia*
10:10 – 10:25	**THE EFFECT OF THE USE OF HEAT PUMPS ON THE PRIMARY ENERGY CONSUMPTION IN SERBIAN SCHOOLS** ***Mirko Stojiljković*, Dušan Ranđelović**, Marko Ignjatović*, Goran Vučković****; * University of Niš, Faculty of Mechanical Engineering in Niš, Niš, Serbia ** University of Niš, Faculty of Civil Engineering and Architecture in Niš, Niš, Serbia*
10:25 – 10:35	**Coffee break**
10:35 – 10:50	**THREATS AND STANDARD SOLUTIONS OF SAFE INDUSTRIAL OT NETWORKS** ***Slavko Dubačkić, Aleksandar Bošković, Đorđe Vladisavljević;*** *CIT, ODS "EPS Distribution", Belgrade, Serbia; Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia; CIT, ODS "EPS Distribution", Belgrade, Serbia*
10:50 – 11:05	**ADVANTAGES OF THE USE OF HEAT PUMPS IN A MUSHROOM CHAMBER DRYER** ***Nikola Milivojević, Damir Đaković;*** *Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
11:05 – 11:20	**OVERVIEW AND RECOMMENDATION OF AVAILABLE TECHNOLOGIES FOR THE IMPLEMENTATION OF TELECOMMUNICATION SUBSYSTEM AS THE PART OF THE DISTRIBUTION SYSTEM AUTOMATION** ***Đorđe Vladisavljević, Slavko Dubačkić, Aleksandar Bošković;*** *CIT, ODS "EPS Distribution", Belgrade, Serbia; Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
11:20 – 11:35	**EXPERIENCES IN THE USE OF SOLAR ENERGY** ***Miodrag Vuković****; Conseko, Belgrade, Serbia*
11:35 – 11:50	**DRAFTING AN ACTION PLAN TO STIMULATE INCREASED USE OF RENEWABLE ENERGY SOURCES AT THE TERRITORY OF THE MUNICIPALITY OF BAČKA PALANKA** ***Zoltan Zavargo****; ENEF Cluster, Novi Sad, Serbia*
11:50 – 12:00	**Coffee break**

FOURTH WORKING SESSION
In the organization of the HVAC Society of Serbia at the SMEITS
REFRIGERATION TECHNIQUES – TRENDS, EXPERIENCES AND APPLICATION

12:00 – 12:15	**REGULATIONS IN THE AREA OF REFRIGERATION TECHNIQUES** ***Slobodan Pejković****; HVAC Society of Serbia at the SMEITS, Belgrade, Serbia*
12:15 – 12:30	**SPECIFICITY OF THE USE AND TECHNICAL SOLUTIONS FOR NATURAL REFRIGERANTS** ***Vladimir Sovilj****; Frigoria, Novi Sad, Serbia*
12:30 – 12:45	**NATURAL REFRIGERANTS – EXPERIENCES IN UTILIZATION** ***Vladimir Beljanski,*** *Danfoss, Serbia*
12:45 – 13:00	**USE OF INDUSTRIAL AMMONIUM HEAT PUMPS IN THE PRODUCTION OF MALT** ***Dragutin Miljković, Nebojša Pejić, Zoran Stajić;*** *Tehnomag-Teco, Novi Sad, Soufflet Serbia, Bačka Palanka, Emerson Commercial & Residential Solutions-Vilter, Belgrade, Serbia*
13:00 – 13:40	**Discussions, conclusions and current information**

CLOSING OF THE XIII FORUM

13:40 – 14:00	**Proposal of Conclusions of the XIII Forum and ceremonial closing of the event** ***Tihomir Simić****; Chairman of the Forum for Clean Energy Technologies, Novi Sad, Serbia*
14:00	**Cocktail**

Urednici Zbornika proširenih apstrakata/
Editors of Extended Abstracts Proceedings:

Vanr. prof. dr Damir Đaković
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Prof. dr Dušan Gvozdenac
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XIII MEĐUNARODNI FORUM O ČISTIM ENERGETSKIM TEHNOLOGIJAMA
„ENERGETSKA DIGITALNA PERSPEKTIVA SRBIJE“ 29-30.10.2019. Novi Sad
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XIII INTERNATIONAL FORUM FOR CLEAN ENERGY TECHNOLOGIES
"ENERGY DIGITAL PERSPECTIVE OF SERBIA" 29-30 October, 2019; Novi Sad
Extended Abstracts Proceedings (CD)

PROŠIRENI APSTRAKTI
EXTENDED ABSTRACTS

KULTUROLOŠKI FAKTORI PONAŠANJA PONAŠANJA KRANJIH POTROŠAČA ENERGIJE I KONKURENTNOST

Valentina B. Ivanić [*]
Cultural Due Diligence Institute, Novi Sad, Srbija

Energetska efikasnost se posmatra kroz gubitke u fazama transformaije, transmisije i distribucije energije, ali i kroz ponašanja kranjih korisnika. Dok se prve tri kategorije mogu posmatrati u zavisnosti od raspoloživih tehnologija, i objasniti tehničkih faktorima, ponašanje kranjih korisnika pored tehničkih može se razumeti samo kroz sagledavanje faktora kulutrološke prirode. Cilj rada je da ukaže vezu između jedne od dimenzija kulture Srbije i intencija kranjih potrošača da usvoje ponašanja koja su okrenuta efikasnoj upotrebi energije. Pod efikasnom upotrebom enerijge se u ovom tekstu operacionalizuje kroz sklonosti ka praćenju potrošnje energije I održavanju njene upotrebe na minimalnom nivou. Dimenzija kulture Srbije (prema Hofstedeu) *koja je negativno korelirana sa energetski efikasnim ponašanjem je distanca moći. Kako se na svetskom tržištu ne takmiče države, već kompanije, tako se i od politika unapređenja energetske efikasnosti očekuje da budu lako i brzo primenjene na lokalnom nivou, preciznije na kompanijskom nivou. Praćenje potrošnje energije na kompanijskom niovu je uslov konkurentnosti i u uslovima digitalizacije postaje sve više izvodljivo u tehničkom smislu. Navedni uslov je neophodan ali ne i dovoljan da u Srbiji kompanije usvoje energetski efikasno ponašanje. U red dovoljnih uslova za energetski efikasno ponašanje kompanija u Srbiji spadaju aktivnosti koji se tiču snižavanja indkesa distance moći.*

Ključne reči: *konkurentnost; energetska efikasnost; digitalizacija; Distanca moći*

1. Uvod

Energetska efikasnost preduzeća, naročito malih i srednjih (u daljem tekstu MSP) je veoma važna, budući da prema podacima Međunarodne Agencije za energetiku [1] pomenuta grupa preduzeća čini 99% preduzeća na globalnom nivou i kreira jednu trećinu tražnje u ukupnoj tražnji za industrijskom energijom na globalnom nivou.

Ako se posmatraju načini na koje MSP utiču na konkurentnost jedne ekonomije, tada je to moguće sagledati kako sa strane tražnje za energijom ali i sa strane uticaja na ponudu energije. U ovom tekstu

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predmet pažnje je konkurentnost MSP sektora koja se može ostvariti reagovanjem na strani tražnje, kroz sagledavanje kulturoloških činilaca koji utiču na mere energetske efikasnosti.

2. Problem, predmet istraživanja i hipoteze

Jedan od najvećih problema sa kojma se sučavaju MSP je nedostatak praksi energetskog meandžmenta [2]. Posvećenost top menadžmenta MSP temi energetskog menadžmenta prepoznaje se kao jedna od barijera koju treba razmotriti prilikom kreiranja politika energetske efikasnosti za MSP [3]. Kao barijere koje spadaju u domen energetski efikasnog ponašanja spadaju i one koje se tiču MSP čije su organizacione strukture rigidne i piramidalne [4] kao i one koje se tiču nedostatka informacija [5]. Navedene prepreke su svojstvene zemljama koje se odlikuju visokom distancom moći. Srbija prema nalazima Hofstedea spada u red zemalja koje odlikuju visoke vrednosti indeksa distance moći [6]. Analiza globalnog konteksta koji odlikuje digitalizacija u svim oblastima, pa i u oblasti energetskog menadžmenta i energetske efikasnosti ukazuje da digitalizacija dovodi do pada vrednosti indeksa distance moći na globalnom nivou.

Kako je indeks distance moći negativno koreliran sa energetski efikasnim ponašanjem, pretpostavka je da će snižavanje vrednosti ovog indeksa na globalnom nivou uticati na snižavanje vrednosti ovog indeksa i u Srbiji, te tako i na efikasniju primenu mera energetske efikasnosti na nivou preduzzeća i jačanje njihove konkurentnosti.

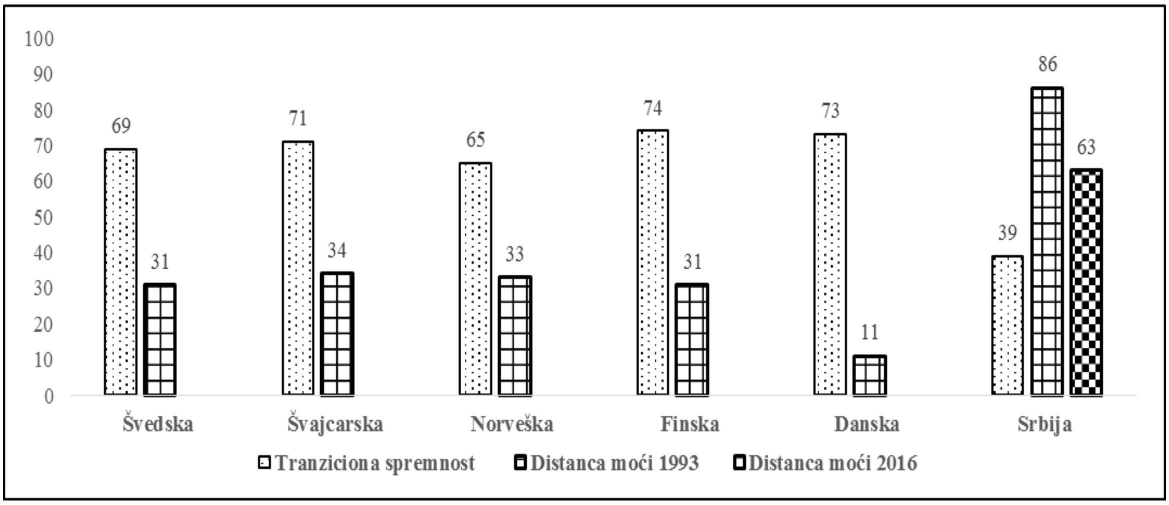
Praksa pokazuje da industrijska MSP u Švedskoj na osnovu primene mera energetske efikasnosti na godišnjem nivou, po preduzeću uštede 340 MWh [7] dok istraživanja u Nemačkoj ukazuju na uštede do 200 MWh na godišnjem nivou po preduzeću [8]. Ukoliko se zna da je bazna cena za MW po satu u Srbiji na dan 21.09. 2019 u visini od 50,32 EUR [9], te da MSP u Srbiji troše do 350 megavat-sati struje godišnje, tada se može veoma lako može imati uvid u vezu između digitalizacije, snižavanja distance moći i uticaja koje mera energetske efikasnosti mogu imati na konkurentnost preduzeća u Srbiji.

3. Metodologija i rezultati

U procesu istraživanja korišćena je metoda komparacija dva tipa indeksa. Upoređivale su se vrednosti indeksa energetske tranzicije i indeksa distance moći za prvih deset zemalja prema rangiranih prema nalazima Svetskog ekonomskog foruma za 2019 godinu i Srbiju. Vrednosti indkesa distance moći za Srbiju uzete su iz Hofstedeovih nalaza za 1993 godinu kao i iz istraživanja autora ovog teksta obavljenih 2016 godine.

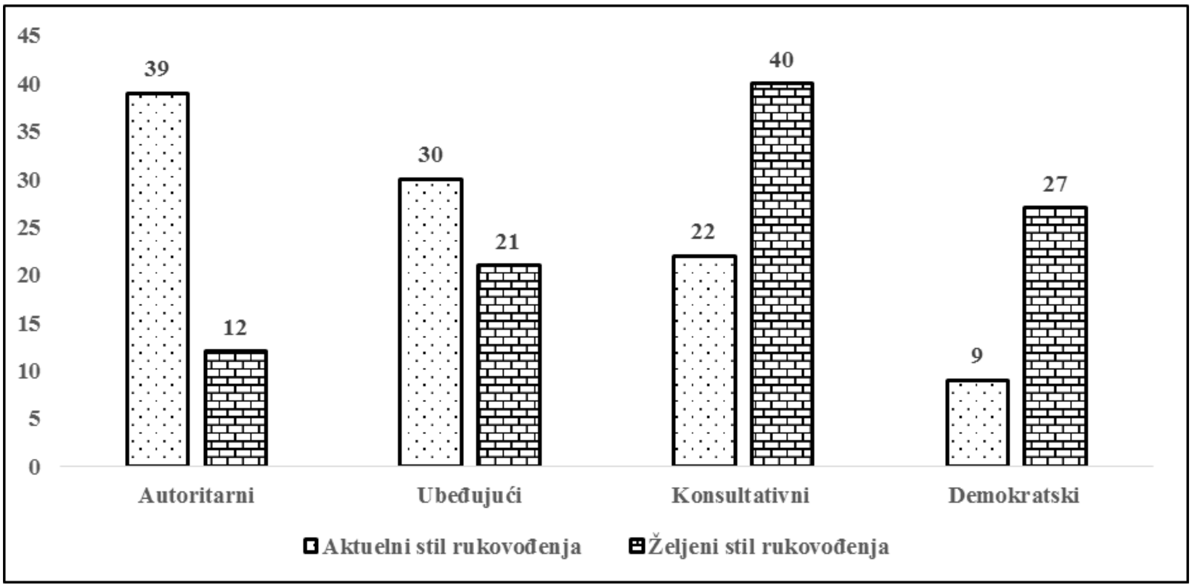
Indeks energetske tranzicije upoređuje energetske sisteme u 115 zemalja, kompozitne je prirode i ukazuje na performantnost sistema i njihovu spremnost za energetsku tranziciju [10]. Važno je ukazati da se zemalje koje se prema indeksu energetske tranzicije nalaze nalaze na prvih deset mesta odlikuju niskim indeksom distance moći, kao i da se Srbija odlikuje visokim indeksom distance moći.

Na globalnom nivou proces digitalizacije dovodi do snižavanja distacne moći, pa je tako došlo do snižavanja vrednosti ovog indeksa i u Srbiji sa vrednosti koja je zabeležena prema Hofstedeovim istraživanjima 1993 godine i koja je iznosila 86 [6] na 63 u 2016 godini [11]. I pored pada vrednosti indeksa distance moći kako je to predstavljeno na Grafikonu 1, Srbija se i dalje svrstava u klaster zemalja visoke distance moći. Takav tip zemalja se na kompanijskom nivou odlikuje autoritranim stilovima upravljanja, izostankom delegiranja, izostankom planiranja i izostankom spremnosti da se izgrade procedure i struktura preduzeća.



Grafikon 1. Tranziciona spremnost i indeks distance moći

Snižavanje vrednosti indeksa distance moći u Srbiji još uvek nije dovelo do promena na nivoima preduzeća, u smislu promena stila upravljanja. Na grafikonu 2 se zapaža dominantnost autoritarnog stila upravljanja u odnosu na ostale stilove upravljanja. Takvom stilu je inherentno praćenje koje je direktno i lično, što isključuje funkcionalnost digitalizacije poslovanja u sferi energetskog menadžmenta.



Grafikon 2. Ocene aktuelnog stila rukovođenja u preduzećima u Srbiji i preferencije ka poželjnom stilu rukovođenja

I pored činjenice da se beleži smanenje indeksa distance moći u Srbiji, kao i činjenice da 40% ispitanika kao poželjni tip rukovodioca priželjkuje konsultativni tip (koji odgovara društvima niske distance moći), kao aktuelni tip rukovođenja još uvek je u velikoj meri prisutan autoritrani tip rukovodioca (39%), kako je predstavljeno na Grafikonu 2.

4. Zaključak

Energetski efikasno ponašanje nije moguće podsticati u sredinama koje neguju autoritrani stil rukovođenja, odnosno u preduzećima koja posluju u društvima visoke distance moći. Digitalizacija na globalnom nivou je u izvesnoj meri uticala na snižavanje indeksa distance moći u Srbiji, ali se Srbija još uvek nalazi u klasteru zemalja visoke distance moći. Takva pozicija čini da se na nivou preduzeća aktuelni stil upravljanja ocenjuje kao autoritativan. Promena stila upravljanja ka poželjnom, konsultativnom dovela bi do pretpostavki za jačanje tranzicione energetske spremnosti Srbije tako energetske efikasnosti i konkurentosti preduzeća koja u Srbiji posluju.

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CULTURAL FACTORS INFLUENCING BEHAVIOUR OF FINAL ENERGY USERS AND COMPETITIVENESS

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Energy efficiency is considered by taking into account the losses during transformation, transmission and energy distribution processes, along with the behaviour of end-users as well. While the first three categories can be observed depending on the technologies available and explained using technical factors; the practice of end-users, besides technical factors, can only be understood while considering cultural factors. The paper aims to identify the link between one of the dimensions of Serbian culture and the intentions of end-users to adopt the forms of behaviour-oriented to efficient energy use. As for efficient energy use, the paper identifies it as a tendency to monitor energy consumption and keep its use to a minimum level. The dimension of Serbian culture (according to Hofstede) that is negatively correlated with energy-efficient behaviour is power distance. As countries, not companies, compete in the global market place, the energy efficiency improvement policies are expected to be easily and quickly implemented locally, that is, at a company level. Monitoring the energy consumption at a company level is a condition of competitiveness, and in the digital era it is becoming more feasible technically. The abovementioned condition is necessary but not sufficient enough for the companies in Serbia to adopt energy-efficient behaviour. The other essential requirements for energy-efficient behaviour of the companies in Serbia include the activities related to lowering the power distance index.

Keywords: *Competitiveness; Energy Efficiency; Digitization; Power Distance*

1. Introduction

Energy efficiency in enterprises, especially small and medium-sized enterprises (from now on referred to as SMEs) is essential since according to the International Energy Agency data [1], this group of enterprises accounts for 99% of the enterprises globally and generates one-third of the total global industrial energy demand.

If we look at how SMEs affect the competitiveness of an economy, it can be observed both from the aspects of energy demand and the impact on energy supply as well. The paper focuses on the

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competitiveness of the SMEs sector, which can be achieved by responding to the demand side by revealing the cultural factors that affect energy efficiency measures.

2. Research problems, research questions and hypotheses

One of the biggest challenges that SMEs are facing is the lack of energy management practices [2]. The commitment of top SMEs management to the idea of energy management is recognised as one of the barriers to be considered when creating energy efficiency policies for SMEs [3]. The obstacles within the domain of energy-efficient behaviour are also the ones concerning SMEs whose organisational structures are rigid and pyramidal [4], as well as those concerning lack of information [5]. These obstacles are typical of the countries characterised by high power distance. According to Hofstede's findings, Serbia is among one of the countries with high power distance [6]. The analysis of the global context characterised by digitisation in all fields, including the areas of energy management and energy efficiency, indicates that digitisation leads to the fall in the value of the power distance index globally.

As the power distance index is negatively correlated with energy-efficient behaviour, the assumption is that lowering the index globally will affect reducing the index in Serbia, along with the more practical application of the energy efficiency measures at a company level while enhancing competitiveness at the same time.

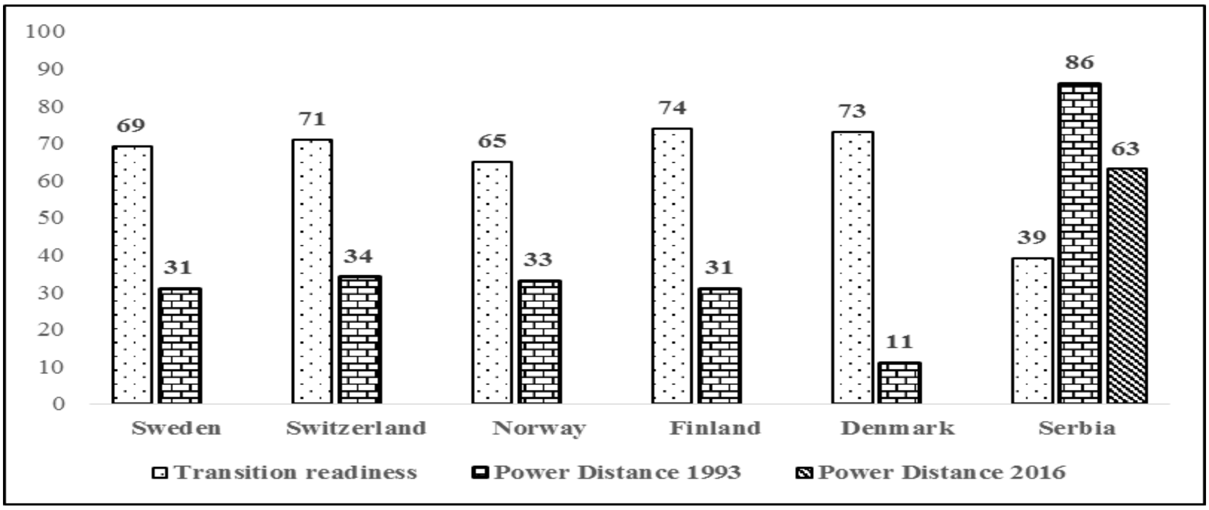
In practice, industrial SMEs in Sweden save 340 MWh per company annually by applying the energy efficiency measures, [7], while the researches in Germany indicate the savings of up to 200 MWh annually per enterprise [8]. Since the base price for MW per hour in Serbia on 21st September 2019 amounted to 50.32 EUR [9], and the SMEs in Serbia consume up to 350 megawatt-hours of electricity per year, the link between digitization, lowering power distance, and the impact that the energy efficiency measures can have on the competitiveness of the companies in Serbia can be easily seen.

3. Methodology and results

The comparison method was used for two types of indexes in the research process. The values of the energy transition index and the power distance index were compared for the top ten countries, ranked according to the findings of the World Economic Forum for 2019, and Serbia as well. The values of the power distance index for Serbia were taken from Hofstede's results for 1993, along with the author’s research conducted in 2016.

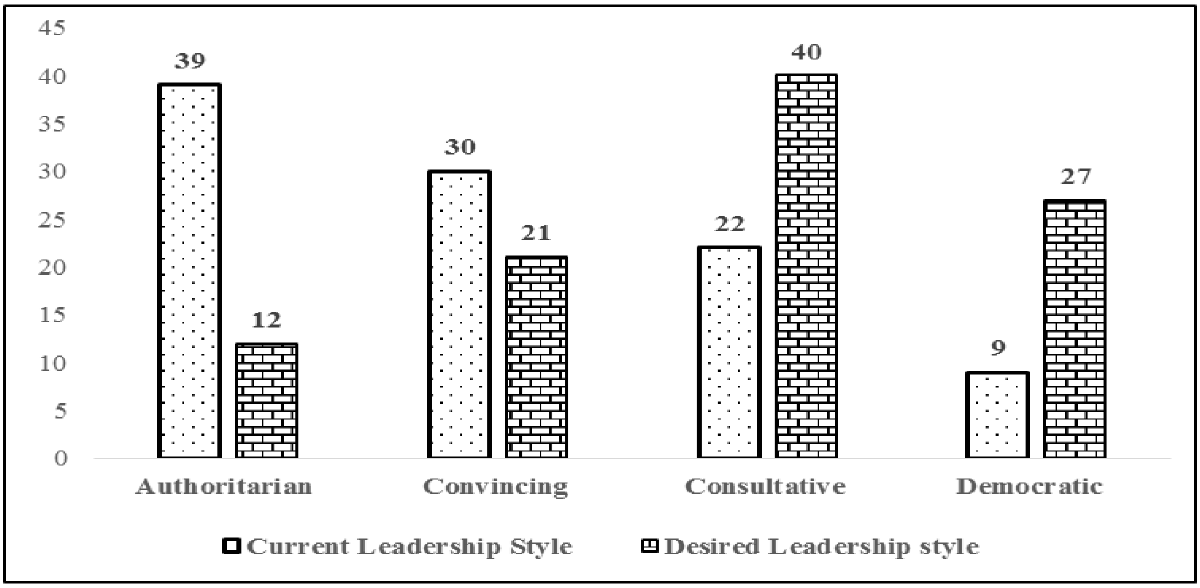
The energy transition index (from now on ETI) compares the energy systems in 115 countries; it is composite and indicates the performance of the systems and their readiness for energy transition [10]. It is essential to point out that the countries ranked in the first ten places (ETI) are characterised by a low power distance index, unlike Serbia which is characterised by a high power distance index.

Globally, the digitalisation process leads to the fall in the value of the power distance index in Serbia from the value recorded according to Hofstede's research in 1993 which amounted to 86 [6] and lowered to 63 in 2016 [11]. Even though the fall in the value of the power distance index is presented in Graph 1, Serbia still belongs to the cluster of the high power distant countries. At a company level, such a type of state is characterised by the authoritarian leadership style, and the lack of the following things: delegation, planning, and readiness to create procedures and the structure of an enterprise.



Graph 1. Transition readiness and power distance index

By lowering the value of the power distance index in Serbia, the changes at a company level in terms of changing leadership styles have not occurred. Graph 2 displays the dominance of the authoritarian leadership style compared to other leadership styles such as participative as well as democratic. Such a style implies directly and personal monitoring, excluding the functionality of digitalisation of business operations in the field of energy management.



Graph 2. Assessments of the current leadership style in Serbian companies and preferred leadership style

Although there is a decrease in the power distance index in Serbia and that 40% of the respondents prefer the consultative leadership style (which suits low power distance cultures as well as companies), the prevailing leadership style is still the authoritative one (39%), as presented in Graph 2.

4. Conclusion

Energy-efficient behaviour cannot be encouraged using the authoritarian leadership style inherent for the high power distance countries as well as companies. Digitalisation at the global level has somewhat contributed to the lowering of the power distance index in Serbia. However, Serbia is still in the cluster of high power distance countries. Consequently, many companies in Serbia implement authoritarian leadership style as actual. Changing the leadership style to a preferred consultative style could lead to enhancing Serbia's readiness for the energy transition, energy efficiency, and competitiveness of companies situated and rooted in the Serbian economy and culture.

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ANALIZA SLOŽENIH ENERGETSKIH SISTEMA UPOTREBOM VEŠTAČKIH NEURONSKIH MREŽA

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Delovanje definisanih i donetih mera i zakona kojima se reguliše sektor energetike i zaštite životne sredine zahteva vreme, kojeg u akutnom problemu klimatskih promena nema. Savremene energetske politike zahtevaju dinamički, fleksibilan i sveobuhvatan pristup kojim se obuhvata celokupan privredni razvoj. U radu je predstavljen model veštačke neuronske mreže (VNM) pomoću, kojeg je na osnovu deset definisanih energetskih indikatora procenjena vrednost emisija CO_2 do 2050. godine za odabrani energetski sistem. Predloženi energetski indikatori opisuju složeni energetski sistem, a njihovom promenom mogu da se simuliraju različiti scenariji ponašanja složenih energetskih sistema na predikciju promene emisije CO_2. Za testiranje predloženog modela izabran je energetski sistem Evropske unije. Dokument Evropske komisije „Energetska mapa puta EU 2050“, korišćen je kao osnova za sagledavanje mogućih i željenih scenarija privrednih razvoja, unutar kojih je i energetski sistem. Analiziran je, pre svega, domet aktuelne politike (business as usual) na smanjenje emisija CO_2 do 2050. godine.

Ključne reči*: energetska politika; veštačke neuronske mreže; energetski sistem; Evropska unija; emisija CO_2*

1. Uvod

Ubrzavanje društvenih i privrednih promena u svetu zahteva iznalaženje dugoročnijih i pouzdanijih predviđanja ponašanja složenih i velikih sistema, ali i pronalaženje načina njihovog efikasnog nadzora i kontinualne korekcije. Po prirodi stvari to je vrlo složen problem, te zahteva i adekvatan matematički alat. Jedan od takvih alata je i veštačka neuronska mreža (VNM). Dizajnirana je za rešavanje složenih problema u kojima se ne može videti jasna veza između ulaza i izlaza i/ili postoje složene nelinearne veze između njih. U ovom radu se demonstrira mogućnost primene ove mreže na složeni energetski sistem EU, ali pod uslovima delovanja energetskih politika naznačenih u Energetskoj mapi puta EU [6]. U tom dokumentu su definisani strateški energetski ciljevi. Taj dokument je osnova za izradu svih nacionalnih energetskih politika članica Evropske Unije (EU), ali su i mnoge druge zemlje koje nisu članice EU, prihavtile taj koncept u izradi sopstvenih energetskih politika. Najvažniji cilj Energy Roadmap 2050, jeste dekarbonizacija društva kroz strukturne privredne promene, što pre svega podrazumeva prestanak proizvodnje energije dobijene iz čvrsih goriva, maskimalnog smanjenja korišćenja naftnih derivata, drastičnog povećanja korišćenja obnovljivih izvora energije, uz neizbežno povećanje energetske efikasnosti svih energetskih transformacija. Najvažniji cilj ovog dokumenta jeste dekarbonizacija privrede kroz strukturne privredne promene i smanjenje emisije CO_2, po nekim od scenarija i za više od 80% u odnosu na 1990. godinu. Sve to se analizira kroz prizmu održivog privrednog rasta i adaptaciju privrede u skladu sa postavljenim ciljem.

Podaci za energetske indikatore su preuzeti iz IEA baze podataka za period 1990-2015. International Energy Agency (IEA), Internacionalne agencije za energetiku http://www.iea.org.

S obzirom na ograničen prostor, ne daje se detaljan pregled literature nego se samo navode osnovne reference kojima se ukazuje i na temu ovog rada.

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2. Modeliranje VNM

Korišćen je programski paket MATLAB 2014a sa dodatkom funkcija za veštačke neuronske mreže (eng. *Neural Network Toolbox*), dodatkom *Contol System Toolbox* za modelovanje i simulaciju sistema, kao i funkcije za obradu podataka. Sistem je modelovan Kaskadnom neuronskom mrežom (eng. *Cascade Forward Neural Network*) sa propagacijom greške unazad, kao algoritmom za korekciju težina i smanjenje greške. Mreža se sastoji od dva skrivena sloja i jednim izlaznim. U prvom skrivenom sloju nalaze se četiri neurona, dok se u drugom nalazi deset. Korišćena je Levenberg-Markart funkcija za obučavanje. Aktivaciona funkcija u skrivenim slojevima je tangens hiperbolična sigmoidalna funkcija, *tansig*, dok je u izlaznom sloju linearna, *purelin* što predstavlja najbolju praksu. Pretprocesiranje podataka je obuhvatilo:

1) Pronalazak trenda svakog indikatora korišćenjem funkcija *polyfit* (za pronalazak polinoma prv og stepena) i *polyval* za izračunavanje novih vrednosti u željenom periodu koje se nalaze u Ma tlabovom Curve Fitting Toolbox-u i
2) Normalizaciju podataka gore pomenutim algoritmom.

3. Energetski indikatori

Za predikciju emisija CO_2 prepoznato je i izdvojeno deset indikatora:

- Bruto domaći proizvod prema (ppp[‡]) iz 2010. godine;
- Prosečna globalna temperatura vazduha;
- Godišnja ukupna potrošnja primarne energije (TPES);
- Godišnja potrošnja električne energije;
- Broj stanovnika;
- Udeo obnovljivih izvora energije u TPES-u;
- Udeo nuklearne energije u TPES-u;
- Udeo energije prirodnog gasa u TPES-u;
- Udeo energije tečnih goriva u TPES-u;
- Udeo energije čvrstih goriva u TPES-u.

Ovih deset indikatora su definisani kao srednje ili samo godišnje vrednosti i uzeti su za period od 1990. do 2015. godine. Godina 1990. je u evropskim dokumentima uzeta kao bazna godina u odnosu na koju se obavlja predviđanje i planiranje delovanja preduzetih mera za unapređenje energetskog sistema EU i njegovih delova. Godina 2015. je poslednja za koju su bili raspoloživi globalni podaci bez posebne naknade.

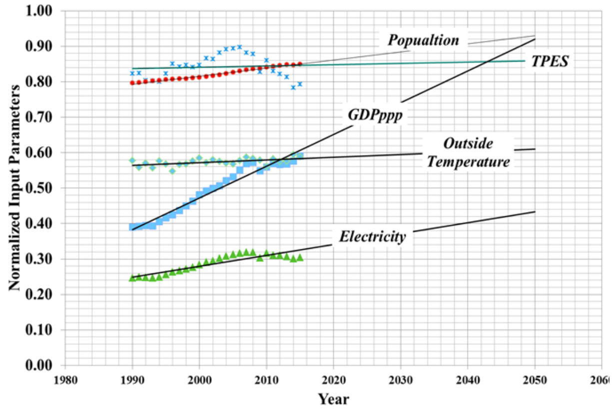
4. Normalizacija

Kod neuronskih mreža najbolja je praksa da se ulazni podaci posebno pripreme kako bi ona efikasnije učila, kako bi vrednosti ulaza bile međusobno uporedive, a samim tim i VNM-a brže pronašla njihove međuzavisnosti. Time bi VNM bila efikasnija sa stanovišta korišćenja memorije, ali bi i dala bolje rezultate simulacije. Osimd toga, i sama logika unutar neuronske mreže radi sa podacima koji su ili u opsegu od -1 do 1 ili 0 do 1 u zavisnosti od aktivacione funkcije koja se koristi u skrivenim slojevima (eng. *activation functions*) [9], te je svođenje svakog indikatora na neki od ovih opsega logičan. Priroda parametara koji se u ovom radu koriste navode na korišćenje intervala normalizacije [0,1], pa su podaci i normalizovani u tom opsegu. Normalizacija predstavlja proces transliranja skupa vrednosti u novi skup, tj. preslikavanje jednog opsega na drugi. U ovom konkretnom slučaju sve vrednosti indikatora (različitih dimenzija i jedinica) se preslikavaju u opseg [0, 1].

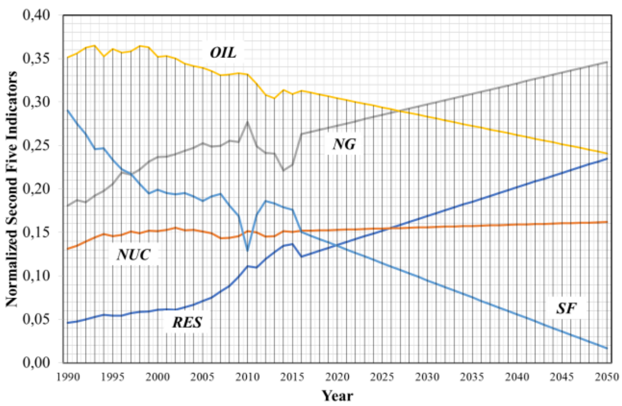
Simulacija i predikcija obavlja se u celom analiziranom periodu 1990-2050. Vrednosti prve grupe idikatora su njihovi trendovi u čitavom periodu 1990-2050. Na slici 1 prikazane su normalizovane vrednosti prvih pet indikatora, kao i njihovi trendovi koji su korišćeni u ulaznom skupu. Vrednosti druge grupe indikatora, za razliku od prve grupe, objedinile su i realne vrednosti iz perioda 1990-2015. i njihov trend 2015-2050. Na slici 2 prikazane su normalizovane vrednosti druge grupe inikatora koji su činili ulazni skup za simulaciju VNM-a.

[‡] Realna kupovna moć valute (Purchasing Power Parity-ppp). Kao osnova je uzeta vrednost USD u 2010. godini.

U zavisnosti od visine greške steći će se slika o količini uticaja prve i druge grupe indikatora na emisiju CO_2. Očekivano je da druga grupa indikatora ima veći uticaj, jer logično, indikatori druge grupe imaju direktniji uticaj na emisiju CO_2. Drugim rečima, očekuje se da greška postoji, ali se i vizuelnim pregledom uočava poklapanje trenda realnih podataka i simuliranih. Trend drugih pet indikatora nisu potpuno prave linije već blago zakrivljene, jer su uzete realne vrednosti (1990-2015) i njihov trend.



Slika 1 – Normalizovani indikatori (prvih pet)



Slika 2 – Normalizovani indikatori (drugih pet)

Najveći udeo u energetskom miksu imaju fosilna goriva (tečna goriva, čvrsta goriva i prirodni gas) čiji je uticaj na emisiju CO_2 presudan.

5. Simulacija, validacija i analiza greške

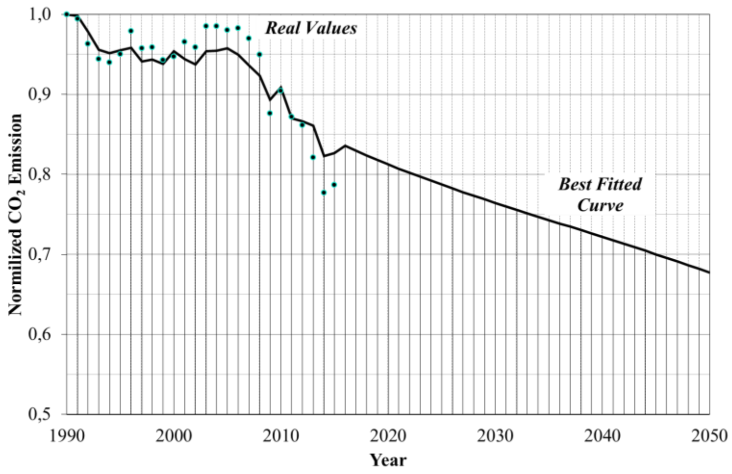
Modelirano je i simulirano sto VNM-a. Izdvojene su samo one mreže koje su zadovoljile sledeća dva kriterijuma:

- Koren srednje kvadratne greške (eng. Root Mean Square Error – RMSE) u periodu 1990-2015 je manji od 0.02 (<2%) i
- Prilikom predikcije emisija CO_2 u 2050. godini (simulirani podaci) mora da bude između 50 i 70%

Evropska komisija je predvidela da će se, ukoliko se nastavi aktuelna politika, do 2050. godine, emisija CO_2 smanjiti sa 100% (referentna 1990. godina) na oko 62%. Ovaj podatak je dobijen na osnovu podataka o trenutnom udelu različitih sektora u potrošnji energije, udelu određenih energetskih resursa u proizvodnji energije, kao i emisionih koeficijenata svih goriva (OIE = 0; Nuklearna = 0, PG = 0.1836, ukupni naftni proizvodi = 0.2517, ČG = 0.3325 $kgCO_2/kWh$). Na osnovu ovoga formiran je drugi kriterijum za izbor mreže, a to je da rezultat simulacije mreže u 2050. godini koristeći aktuelnu politiku treba da bude u intervalu od ±10% od vrednosti koju je predvidela Evropska komisija.

Od 100 mreža koje su modelirane i simulirane izdvojeno je 78 mreža koje su zadovoljile prvi kriterijum (greška manja od 2%), a ukupno njih 30 su zadovoljile oba gore pomenuta kriterijuma. Na slici 3 su prikazani originalni podaci i rezultat simulacije mreže jedne od 30 izdvojenih mreža sa najmanjom greškom, na kojoj se jasno vidi da je mreža uspela da potpuno nauči ponašanje sistema (trend realnih podataka je ispraćen). Od 30 izdvojenih rezultata kriva sa najmanjom srednjom kvadratnom greškom prikazana je na slici 3 i uzeta je kao konačno rešenje.

Pošto ova kriva od svih krivih najbolje opisuje poznati period, odnosno VNM koja je dala ovaj rezultat je najbolje obučena, pretpostavlja se da će i izvan tog perioda najbolje predvideti promenu emisjie CO_2. Prema predikciji, ako se aktuelna energetska politika nastavi i u vremenu nakon obuke, VNM-a procenjuje da će u 2050. godini emisija CO_2 pasti na 67.7% u odnosu na izmerenu vrednost iz 1990. godine.



Slika 3 – Realne vrednosti i izlazne vrednosti VNM-a procene emisije CO_2

6. Zaključak

Ovo istraživanje pokazuje da veštačke neuronske mreže uspešno mogu da se koriste za analizu i upravljanje složenim energetskim sistemima.

Test je obavljen na složenom i velikom energetskom sistemu EU, a testirana je i sveobuhvatna startegija razvoja energetike EU 28 do 2050. godine i praktično verifikovao ciljanu emisiju CO2 u 2050-toj godini uz uslov da se u celom analiziranom periodu sprovodi sadašnja politika (business as usual).

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ANALYSIS OF COMPLEX ENERGY SYSTEMS BY MEANS OF ARTIFICIAL NEURAL NETWORKS

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The effects of defined and adopted measures and laws regulating the energy sector and environmental protection require time which does not exist in the acute problem of climate change. Modern energy policies require dynamic, flexible and comprehensive approach that encompasses the whole economic development. This paper presents the model of the artificial neural network (ANN) which is used to estimate the value of CO_2 emissions by 2050 for the selected energy system on the basis of ten defined energy indicators. The proposed energy indicators describe the complex energy system and by their change it is possible to simulate different scenarios of behavior of complex energy systems with reference to the prediction of the change of CO_2 emissions. The energy system of the European Union is selected to test the proposed model. The document of the European Commission the "EU Energy Roadmap 2050" is used as the basis for examining possible and desired scenarios of the economic development within which there is the energy system, as well. First of all, the reach of the current policy (business as usual) on the reduction of CO_2 emissions by 2050 is analyzed.

Keywords*: Energy Policy; Artificial Neural Networks; Energy System; European Union; CO_2 emissions*

1. Introduction

The acceleration of social and economic changes in the world requires not only finding long term and more reliable predictions of behavior of complex and large systems but also finding ways of their efficient supervision and continuous adjustment. By nature, this is a very complex problem and requires an adequate mathematical tool. One of such tools is the artificial neural network (ANN). It is designed to solve complex problems in which clear connection between inputs and outputs cannot be seen and/or when there are complex nonlinear connections between them. This paper demonstrates the possibility of applying this network to the complex EU energy system but under conditions affected by energy policies outlined in the EU Energy Roadmap [6]. In that document, strategic energy objectives are defined. Although that document is the basis for the preparation of all national energy policies of Member States of the European Union (EU), many other countries that are not EU members have accepted this concept in developing their own energy policies. The most important objective of the Energy Roadmap 2050 is decarbonization of the society through structural economic changes which primarily entail the end of the production of power from solid fuels, maximum reduction of the use of oil derivatives, drastic increase of the use of renewable energy sources, all that accompanied by the inevitable increase of energy efficiency of all energy transformations. The most important goal of that document is the decarbonization of the economy through structural economic changes and the reduction of CO_2 emissions by more than 80% in relation to 1990 according to some scenarios. All this is analyzed through the prism of sustainable economic growth and adaptation of the economy in line with the preset objectives.

Data for energy indicators are taken over from the IEA database for the period 1990-2015, International Energy Agency (IEA), http://www.iea.org.

Taking into account limited space, there is no detailed overview of literature and only basic references related to the topic of this paper are given.

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2. ANN Modeling

The MATLAB 2014a program package with the addition of functions for artificial neural networks (*Neural Network Toolbox*) and the addition of the *Control System Toolbox* for modeling and simulation of the system, as well as functions for data processing functions, is used. The system is modeled with a *Cascade Forward Neural Network* with backward error propagation as an algorithm for weight correction and error reduction. The network consists of two hidden layers and one output layer. In the first hidden layer, there are four neurons, while in the other one, there are ten. The Levenberg-Marquardt function is used for training purposes. The activation function in hidden layers is a tangent hyperbolic sigmoidal function, *tansig*, while, in the output layer, the function is a linear, *purelin*, which is the best practice. Data preprocessing includes the following:

3) The trend of each indicator is found by means of the function *polyfit* (for finding the first degr ee) and *polyval* for calculating new values in a desired period that are found in the MATLAB Curve Fitting Toolbox and
4) Data normalization by means of above mentioned algorithm.

3. Energy Indicators

Ten indicators are recognized and singled out for the prediction of CO_2 emissions:

- Gross domestic product according to the ppp[§] in 2010;
- Average global air temperature;
- Annual total primary energy supply (TPES);
- Annual electricity consumption;
- Number of population;
- Share of renewable energy sources in TPES;
- Share of nuclear energy in TPES;
- Share of natural gas energy in TPES;
- Share of liquid fuels energy in TPES;
- Share of solid fuels energy in TPES.

These ten indicators are defined as medium or only as annual values and they are taken for the period from 1990 to 2015. In European documents, the year 1990 is taken as the base year and the prediction and planning of effects of undertaken measures for the improvement of the EU energy system and its parts are made in relation to this year. The year 2015 is the last year for which global data are available without special compensation.

4. Normalization

For neural networks, the best practice is to prepare input data separately so that it can learn more efficiently, so that that input values are mutually comparable and thus, the ANN will find their interdependencies faster. This will make the ANN more efficient from the standpoint of the memory use and it will also give better results of simulation. In addition, the logic itself within the neural network operates with data that are either in the range from -1 to 1 or from 0 to 1 depending on activation functions that are used in hidden layers [9] and the reduction of each indicator to one of these ranges is logical. The nature of parameters that are used in this paper induce the use of the normalization interval [0, 1] so, data are normalized in that range. Normalization represents the process of translation of the set of values into a new set, i.e. reproduction of one range onto the other. In this particular case, all values of indicators (with different dimensions and units) are reproduced into the range [0, 1].

Simulation and prediction are carried out throughout the whole analyzed period 1990-2050. The values of the first group of indicators are their trends throughout the whole period 1990-2050. The Figure 1 shows normalized values of the first five indicators, as well as their trends that have been used in the input set. The values of the second group of indicators, unlike the first group, have put together real values from the period 1990-2015 and their trends from 2015-2050. The Figure 2 shows

[§] Purchasing Power Parity – ppp, the USD value in 2010 is taken as the basis normalized values of the second group of indicators that form the input set for the ANN simulation.

Depending on the size of the error, the idea will be obtained about the size of influence of the first and of the second group of indicators on CO_2 emissions. It is expected that the second group of indicators has a greater impact, because logically, indicators of the other group have more direct impact on CO_2 emissions. In other words, it is expected that the error exists but even visual examination shows overlapping between trends of real data and simulated ones. Trends of other five indicators are not fully straight lines but slightly curved ones because real values (1990-2015) and their trends are taken.

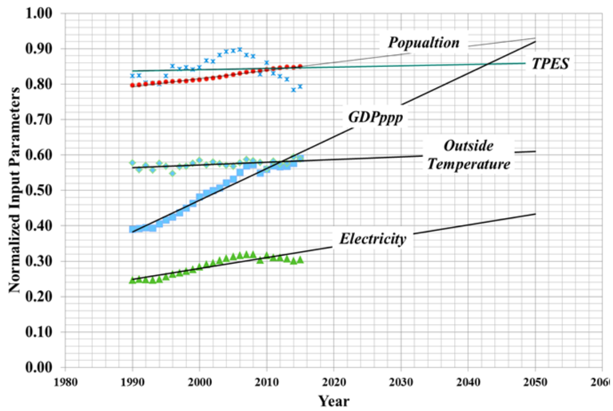

Figure 1 – Normalized Indicators (First Five)

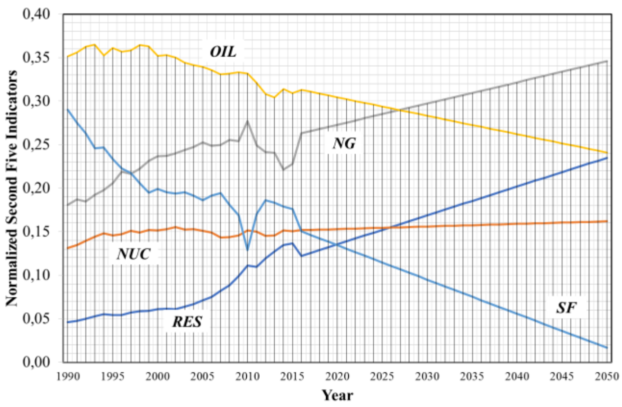

Figure 2 – Normalized Indicators (Second Five)

The largest share in the energy mix is that of fossil fuels (liquid fuels, solid fuels and natural gas) whose influence on CO_2 emissions is decisive.

5. Simulation, Validation and Error Analysis

One hundred ANNs are modeled and simulated. Only those networks that satisfy two criteria specified below are singled out:

- The root mean square error – RMSE in the period 1990-2015 is lower than 0.02 (<2%) and
- With reference to predictions, CO_2 emissions in 2050 (simulated data) have to be between 50 and 70%

The European Commission has predicted that if the current policy is continued, CO_2 emissions by 2050 will be reduced from 100% (reference year is 1990) to around 62%. This data is obtained on the basis of data on the current share of different sectors in energy consumption, the share of certain energy sources in the production of energy and emission coefficients of all fuels (RES = 0; Nuclear = 0, NG = 0.1836, total oil products = 0.2517, SF = 0.3325 kgCO_2/kWh).Based on this, another criterion for the selection of the network is formed and it implies that the result of the network simulation in 2050 using the current policy should be within the range of ± 10% of the value envisaged by the European Commission.

Out of 100 networks that are modeled and simulated, 78 networks that satisfy the first criterion (the error less than 2%) are singled out and totally 30 of them satisfy both above mentioned criteria. The Figure 3 shows original data and the result of the network simulation of one of 30 singled out networks with the smallest error which clearly shows that the network has managed to fully learn the behavior of the system (the trend of real data is observed). Out of 30 singled out results, the curve with the smallest mean square error is shown in Figure 3 and it is taken as the final solution.

Since out of all curves this curve describes the known period the best, that is, the ANN that gives this result has been trained the best. Therefore, it is assumed that even beyond this period it will predict the change of CO_2 emissions in the best possible way. According to the prediction, if the current energy policy is continued at the time after the training period, the ANN estimates that in 2050, CO_2 emissions will fall to 67.7% in relation to the value measured in 1990.

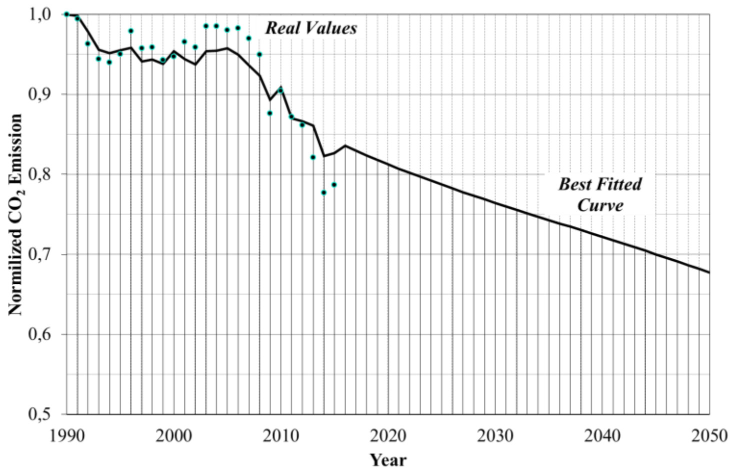

Figure 3 – Real Values and Output ANN Values of CO_2 Emissions Estimates

6. Conclusion

This research shows that artificial neural networks can be successfully used to analyze and to manage complex energy systems.

The test is carried out on the complex and large energy system of the EU and the comprehensive strategy for the EU 28 energy development until 2050 is also tested and targeted CO_2 emissions in 2050 are practically verified provided the current policy (business as usual) is implemented throughout the whole analyzed period.

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BIOEKONOMIJA – NOVI KONCEPT PRIVREDNOG RAZVOJA SA ZNAČAJNIM UTICAJEM NA BUDUĆE ENERGETSKE POLITIKE

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Živimo u svetu ograničenih resursa. Globalni izazovi poput klimatskih promena, degradacija zemljišta i ekosistema, u kombinaciji sa rastućim brojem stanovništva prisiljavaju sve donosioce odluka da tragaju za novim načinima proizvodnje i konzumiranja koji poštuju ekološke granice naše planete. U isto vreme, potreba za postizanjem održivosti predstavlja snažan podsticaj za modernizaciju industrije i za jačanje njene pozicije u visoko konkurentnoj globalnoj ekonomiji. Globalni izazovi zahtevaju globalna rešenja. Bioekonomija bi mogla biti naznačajniji deo budućeg razvojnog koncepta.

Ključne reči: bioekonomija; energetske politike; Srbija

1. Bioekonomija i Evropska unija

Evropa se suočava sa neodrživom eksploatacijom svojih prirodnih resursa. Ova pojava je praćena sa značajnim i potencijalno nepovratnim klimatskim promenama i stalnom degradacijom biodiverziteta što ugrožava stabilnost živih sistema na kojima počiva naš opstanak. Cela slika se pogoršava usled očekivanog porasta svetske populacije za više od 30% u narednih 40 godina. Ovi složeni i međusobno povezani izazovi zahtevaju istraživački napor i inovacije kako bi se postigle brze, usaglašene i održive promene u načinu života i upotrebi resursa na svim nivoima društva i ekonomije. Dobrobit i blagostanje evropskih građana i budućih generacija će zavisiti od toga kako će se izvršiti ova neizbežna transformacija [1-3].

Konferenciju o bioekonomiji zasnovanoj na znanju pod sloganom „Transformacija znanja o prirodnim naukama u nove, održive, eko-efikasne i konkurentne proizvode", održana je 2005. godine u Ujedinjenom Kraljevstvu. Tokom predsedavanja Nemačke ova inicijativa je podržana i 2007. godine i organizovna je konferencija pod nazivom „Na putu razvoja bio-ekonomije zasnovanoj na znanju “, gde je predstavljen dokument koji je pripremio tim stručnjaka iz akademske i poslovno-industrijske zajednice, iznoseći svoju viziju perspektive za razvoj bioekonomije u Evropi u narednih 20 godina. Tema bioekonomije je prepoznata kao prioritet i tokom predsedavanja Belgije, što je za posledici imalo organizovanje konferencije “Bio-ekonomija zasnovana na znanju do 2020. godine”, koja je održana 13. i 14. septembra 2010. godine. Konačno je Evropska komisija 13. februara 2012. godine usvojila strategiju pod naslovom “Inovacije za održivi rast: Bioekonomija za Evropu”. Ova strategija predlaže sveobuhvatan pristup za rešavanje ekoloških izazova sa kojima se suočavaju i Evropa, i svet danas, kao i sa izazovima u oblasti energetike, sigurnosti snabdevanja hranom i korišćenja prirodnih resursa [1] [4] [2]. Svestrana priroda bioekonomije pruža jedinstvenu priliku za sveobuhvatno rešavanje međusobno povezanih društvenih izazova i identifikuje pet ciljeva kojima strategija i njen akcioni plan doprinose: (1) obezbeđivanju sigurnosti snabdevanja hranom, (2) održivo upravljanje prirodnim resursima, (3) smanjenju zavisnosti od neobnovljivih resursa, (4) ublažavanje i prilagođavanje klimatskim promenama i (5) kreiranje novih radnih mesta i održavanje konkurentnosti Evropske unje [5] .

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Okvirne procene pokazuju da svi sektori bioekonomije u Evropskoj uniji generišu oko 2 triliona evra vrednosti mereno u godišnjem prometu. Bioekonomski sektori zapošljavaju više od 22 miliona ljudi što čini oko 9% radne snage. Očekuje se da će značajan rast ovog privrednog segmenta biti posledica ulaganja u održivu primarnu proizvodnju, preradu hrane, razvoj biotehnologija i njihova primena u industriji. Sve to dovodi do pojave novih bio-baziranih industrija, kao i transformacije postojećih. Kroz ovaj proces se kreiraju nova tržišta bazirana isključivo na proizvodima biološkog porekla. Bioekonomija prema tome pokriva sve sektore i sisteme koji se oslanjaju na biološke resurse kao što su: životinje, biljke, mikroorganizmi i izvedena biomasa, uključujući organski otpad.

Nakon donošenja prve strategije koja se odnosi na bioekonomiju 2012. godine Evropska unija je posvetila značajnu pažnju temama koje imaju za cilj ojačavanje veza između ekonomije, društva i životne sredine. To su u prvom redu politike koje se odnose na: obnovljivu industrijsku politiku, kružnu, odnosno, cirkularnu ekonomiju i paket politika i mera pod nazivom „Čista energija za sve evropljane“, Ova bogata aktivnost nametnula je potrebu da se izvrši prvo usklađivanje i unošenje novih sadržaja u tekst Strategije za bioekonomiju. To je realizovano donošenjem dokumenta pod nazivom „Održiva bioekonomija za Evropu: jačanje veza između ekonomije, društva i životne sredine“ [6], što je učinjeno u oktobru 2018. godine.

2. Bioekonomija i energetske politike

Evropska ekonomija se u velikoj meri oslanja na fosilne resurse i izvore energije, Da bi ostala konkurentna, ekonomija Evropske unije i celokupno društvo treba u što kraćem roku da se transformišu u nisko ugljeničnu zajednicu u kojoj se efikasno i održivo koriste resursi, u kojoj dominiraju bio-bazirani proizvodi i bioenergija, koji skupa doprinose zelenoj proizvodnji i obezbeđuju dalji rast i konkurentnost.

Danas bioenergija predstavlja najznačajniji izvor obnovljive energije u obnovljivom energetskom miksu Evropske unije, a očekuje se da će 2030. godine postati ključna energetska komponenta uključujući i konvencionalne izvore. Može se uočiti značajna povezanost bioekonomije i relevantnih energetskih politika kroz sledeći zakonodavni okvir koji je na snazi:

- Obnovljiva energija Evropske unije - EU Renewable Energy Directive (2009/28/EC)
- Saopštenje Komisije „Energetske politike za Evropu“ - Commission communication „An energy policy for Europe“ (EC 2007a)
- Saopštenje Komisje „ Evropski strategijski plan energetskih tehnologija (SET plan) – prema nisko-karbonskoj budućnosti “ - Commission communication „A European strategic energy technology plan (SET-plan) — Towards a low carbon future“ (EC 2007b)
- Saopštenje Komisije „Ograničavanje globalnih klimatskih promena do 2 stepena Celzijusa – put prema 2020 i posle“ - Commission communication „Limiting global climate change to 2 degrees Celsius — The way ahead for 2020 and beyond“ (EC 2007c)
- Saopštenje Komisije „Energija 2020 – Strategija za konkurentnost, održivost i energetsku sigurnost - Commission communication „Energy 2020 — A strategy for competitive, sustainable and secure energy“ (EC 2010f)
- Saopštenje Komisije „ Energetska mapa puta do 2050“ - Commission communication „Energy roadmap 2050“ (EC 2011d)
- Saopštenje Komisije „ Okvir za politike o klimi i energiji u periodu od 2020 do 2030“ - Commission communication „A policy framework for climate and energy in the period from 2020 to 2030“ (EC 2014a)
- Saopštenje Komisije „Ubrzanje evropske tranzicije ka nisko-karbonskoj ekonomiji“ - Commission communication: „Accelerating Europe’s transition to a low-carbon economy“ (EC 2016k)
- Paket o čistoj energiji - Clean Energy Package (2016)

- Saopštenje Komisije „Uloga transformacije otpada u energiju u cirkularnoj ekonomiji“ - Commission communication „The role of waste-to-energy in the circular economy“, (EC 2017a)

Procenjuje se da u ovom momentu gradovi proizvode oko 1,3 milijarde tona čvrstog otpada godišnje. Oko polovina ove ogromne količine je organskog porekla. Urbani biootpad se često doživljava kao veliki izazov za urbanističke planere i menadžere komunalnih preduzeća, zbog potencijalnog pritiska na životnu sredinu i zdravlje stanovnika. Istovremeno, tokovi biootpada u gradovima sadrže supstance koje bi mogle da se koriste za različite vidove proizvodnje na bazi biomaterije. Grad Amsterdam procenjuje da bi boljim upravljanjem tokovima recikliranja otpada i organskih ostatka mogli da pokrenu proizvodnju od 150 miliona evra dodane vrednosti godišnje. Ova aktivnost bi doprinela da se kreira 1.200 novih radnih mesta na duži rok i uštedi oko 600.000 tona ugljen dioksida godišnje. Ako bi 50 najvećih evropskih gradova primenili ovaj vizionarski plan, tada bi se efekti merili na između 7,5 i 12 milijardi evra ekonomskog dohotka dodate vrednosti, dok bi posao našlo između 60.000 i 100.000 radnika i doprinos u smanjenju emisije gasova staklene bašte bi se merio uštedom emisije ugljen dioksida od 30 do 50 megatona. Danas posedujemo konvencionalne tehnologije za preradu gradskog biootpada u kompost i biogas, koji se uglavnom koristi kao energent. Pored toga postoje mogućnosti za unapređenje i dalje iskorištavanje ovih potencijala na inovativan način. Nova regulativa Evropske unije o otpadu trebalo bi da dovede do povećanja količina koja bi bile dostupna za tretman [6].

3. Bioekonomija i aktivnosti u Srbiji

Razvoj bioekonomije kao celovitog, sveobuhvatnog koncepta razvoja ekonomije koji vodi računa o potrebama društva i ima senzibilitet za očuvanje životne sredine u Srbiji je na samom početku. Iz perspektive dosadašnjeg iskustva i primenjene prakse razvijenih država članice EU, očito je da su u Srbiji, a naročito na teritoriji Vojvodine, locirani značajni resursi i da postoji uspostavljena razvojna i naučno-istraživačka baza, kao i određena privredna tradicija kao neophodno polazište za razvoj bioekonomije .
U prethodnom periodu, domaći akteri u saradnji sa partnerima iz država u okruženju posvećeno su radili na podizanju svesti i edukaciji ključnih činilaca budućeg bioekonomskog razvoja, a to su: preduzeća, istraživačko-razvojne institucija i predstavnici javnog sektora. Ova aktivnost sprovedena je u okviru nekoliko projekata finansiranih od strane EU (DanuBioValNet, Made in Danube, S3 CLUSTERS, Bio-Economy R.D.I). Iskustva govore da međunarodna saradnja u ovoj oblasti, naročito kod zemalja u okruženju koje imaju sličnosti u raspoloživim resursima i ekonomskoj strukturi, pomaže regionima da se lakše specijalizuju i fokusiraju na sopstvene konkurentske prednosti u cilju stvaranja dodatne vrednosti. Tokom Poljoprivrednog sajma organizovanog u maju 2019. godine okupili su se partneri iz šest država (Italija, Slovenija, Hrvatska, Grčka, Albanija i Srbija) koji rade na projektu Bio-Economy R.D.I. [7]:

Ovaj projekt ima za cilj razvoj regionalnog inovacijskog sistema za jadransko-jonsku oblast zasnovanog na sektoru bioekonomiji kroz razvoj inovacija. Jedan od njegovih rezultata biće i ponuđena strategija na regionalnom i transnacionalnom nivou koja treba da poboljša trenutnu situaciju kroz sledeće aktivnosti:

- kreiranje mreže koja će omogućiti intezivnu suradnje između predstavnika Adrion regiona, preduzeća i akademske zajednice radi zajedničkih istraživanja, transfera znanja i razvoja veština
- podrške preduzećima i klasterima u procesu tranzicije ka industrijskom modelu sa višim nivoom inovacija i međunarodnom saradnjom

- jačanje integracije između „zelene hemije“ i poljoprivredno-prehrambenih klastera u skladu sa principima cirkularne ekonomije
- formiranje jadransko-jonskog tržišta proizvoda zasnovanih na biološkoj osnovi
- premošćavanje jaza među postojećim širokim regionalnim nejednakostima
- aktiviranje procesa međusobnog učenja među regionima sa različitim nivoima zrelosti bioekonomskog poslovanja

4. Zaključak

Bioekonomija zahteva kontinuiranu i sve veću finansijsku podršku iz izvora javnih sredstava i rast privatnih investicija da bi se doprinelo boljoj koherentnosti između nacionalnih, evropskih i globalnih tokova informacija i znanja i premostile institucionalne i konceptualne barijere između istraživača, inovatora, proizvođača, krajnjih korisnika, kreatora politike i civilnog društva. Mreže za prenos znanja, brokeri znanja i tehnologije, kao i socijalno preduzetništvo, mogu premostiti te praznine.
Standardi su od presudne važnosti za razvoj označavanja bio-baziranih proizvoda što igra značajnu ulogu u njihovoj komercijalizaciji. Potrebno je pružiti potrošačima jasnu informaciju o ekološkim performansama proizvoda i tako uticati na njihov preferencijalni izbor. Oznake mogu biti presudne za prihvatanje bio-baziranih proizvoda od strane države i njenih institucija kao velikog potencijalnog kupca kroz podsticaje uvedene preko mehanizma „zelenih javnih nabavki“.
Bioenergija i paket politika koje podržavaju povećanje učešća bioenergije u budućem energetskom miksu su neizostavni i izuzetno značajan deo ove transformacije. Ovaj proces obezbeđuje preduzećima da mogu očekivati poslovanje na unapređenom i integrisanom tržištu i da ukaže i ponudi regionalnim i nacionalnim kreatorima relevantnih politika neophodnu podršku u dizajniranju efikasnih politika zasnovanih na pristupu cirkularne ekonomije i bioekonomije.

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BIOECONOMY – A NEW CONCEPT OF FUTURE ECONOMIC DEVELOPMENT WITH SIGNIFICANT IMPACT ON FUTURE ENERGY POLICIES

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We live in a world of limited resources. Global challenges such as climate change, land and ecosystems degradation, combined with growing populations, are forcing all decision-makers to seek new ways of production and consumption that respect the ecological boundaries of our planet. At the same time, the need to achieve sustainability is a strong motive for modernizing the industry and for strengthening its position in a highly competitive global economy. Global challenges require global solutions. Bioeconomy could be a significant part of a future development concept.

Keywords: *bioeconomy; energy policy; Serbia*

1. Bioeconomy and the European Union

Europe is facing an unsustainable exploitation of all its natural resources. This phenomenon is accompanied by significant and potentially irreversible climate change and the constant degradation of biodiversity, which threatens the stability of living systems on which our survival depends. The whole picture is worsening due to the world population's expected increase of more than 30% over the next 40 years. These complex and interconnected challenges require research effort and innovation to achieve rapid, harmonized and sustainable change in lifestyles and resource utilization at all levels of society and economy. The well-being of European citizens and future generations will depend on how this inevitable transformation is accomplished [1] [2] [3].

Knowledge-based bioeconomy conference under the slogan „Transforming life sciences knowledge into new, sustainable, eco-efficient and competitive products", it was held in 2005 in the United Kingdom. The German Presidency supported this initiative and hosted in 2007 a conference entitled "En Route to the Knowledge-Based Bio-Economy", where a document prepared by a team of experts from the academic and business-industrial communities was presented, outlining their vision of the prospect of developing a bioeconomy in Europe over the next 20 years. The topic of bioeconomy was recognized as a priority during the Belgian presidency, which resulted in the organization of the conference „The knowledge based bioeconomy towards 2020", which was held on September 13 and 14, 2010. Finally, on 13 February 2012, the European Commission adopted a strategy entitled „Innovating for Sustainable Growth: A Bioeconomy for Europe". This strategy proposes a comprehensive approach to address the environmental challenges facing both Europe and the world today, as well as challenges in the areas of energy, food security and the use of natural resources [1] [4]. The complex nature of bioeconomy provides a unique opportunity to comprehensively address interconnected societal challenges and identify five goals that the strategy and its action plan contribute to: (1) ensuring food security, (2) sustainable management of natural resources, (3)

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reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change and (5) creating jobs and maintaining European Union competitiveness [5] .
The European Union's bioeconomy sectors are worth € 2 trillion in annual turnover and account for more than 22 million jobs and approximately 9% of the workforce. Significant growth of this economic segment is expected to result from investments in sustainable primary production, food processing, development of biotechnologies and their application in industry. All this leads to the emergence of new bio-based industries, as well as the transformation of existing ones. Through this process, new markets are created based on products of biological origin. Bioeconomy therefore covers all sectors and systems that use biological resources such as: animals, plants, micro-organisms and derived biomass, including organic waste.

Since the adoption of the first bioeconomy strategy in 2012, the European Union has paid considerable attention to topics aimed at strengthening the links between the economy, society and the environment. These are primarily policies relating to: renewable industrial policy, circular economy and a package of policies and measures called "Clean Energy for All Europeans". This activity imposed the need to first align and incorporate new content into the text of the Bioeconomy Strategy. This is realized by the document "A sustainable bioeconomy for Europe: stengthening the connection between economy, society and the environment" [6], which was proclaimed in October 2018.

2. Bioeconomy and energy policies

The European economy is predominantly using fossil resources and energy sources. In order to remain competitive, the EU economy and society at large should be transformed into a low-carbon, resource-efficient and sustainable economy dominated by bio-based products and bio-energy, which together contribute to green production and provide further growth and competitiveness.
Today, bioenergy is the most significant source of renewable energy in the European Union's renewable energy mix, and is expected to become a key energy component in 2030 including conventional sources. A significant link between bioeconomy and relevant energy policies can be observed through the following legislative framework in force:

- EU Renewable Energy Directive (2009/28/EC)
- Commission communication „An energy policy for Europe“ (EC 2007a)
- Commission communication „A European strategic energy technology plan (SET-plan) — Towards a low carbon future“ (EC 2007b)
- Commission communication „Limiting global climate change to 2 degrees Celsius — The way ahead for 2020 and beyond“ (EC 2007c)
- Commission communication „Energy 2020 — A strategy for competitive, sustainable and secure energy“ (EC 2010f)
- Commission communication „Energy roadmap 2050“ (EC 2011d)
- Commission communication „A policy framework for climate and energy in the period from 2020 to 2030“ (EC 2014a)
- Commission communication: „Accelerating Europe's transition to a low-carbon economy“ (EC 2016k)
- Clean Energy Package (2016)
- Commission communication „The role of waste-to-energy in the circular economy“, (EC 2017a)

It is estimated that cities currently produce around 1.3 billion tons of solid waste per year. About half of this huge amount is of organic origin. Urban bio-waste is often seen as a major challenge for urban planners and utility managers, due to the potential environmental and health pressures on residents. At the same time, bio-waste streams in cities contain substances that could be used for different types of biomaterial-based production. The City of Amsterdam estimates that better management of waste recycling and organic waste streams could trigger production of € 150 million of value added per year. This activity would help create 1,200 new jobs in the long term and save about 600,000 tons of carbon dioxide a year. If this visionary plan were implemented by the 50 largest European cities, then the effects would be measured at between 7.5 and 12 billion euros of economic value-added income, while jobs would find between 60,000 and 100,000 workers and the contribution to reducing greenhouse gas emissions would be measured saving carbon dioxide emissions from 30 to 50 megatons. Today we have conventional technologies for recycling urban bio-waste into compost and biogas, which is mainly used as an energy source. In addition, there are opportunities to harness these potentials in an innovative way. The new European Union waste regulation should increase the quantities available for treatment [6].

3. Bioeconomy and activities in Serbia

The development of bioeconomy as a comprehensive concept of economic development that takes into account the needs of society and has a sensitivity to environmental protection in Serbia is at the very beginning. From the experience and practice of developed EU Member States, it is obvious that significant resources have been located in Serbia, especially in the territory of Vojvodina, and that there is an established scientific and research base, as well as a certain economic tradition as a necessary starting point for the development of bioeconomy.

In the previous period, domestic actors, in cooperation with partners from the surrounding countries, have been dedicated to raising awareness and educating key factors of future bioeconomic development, namely: companies, research and development institutions and public sector representatives. This activity has been carried out within several EU funded projects (DanuBioValNet, Made in Danube, S3 CLUSTERS, Bio-Economy R.D.I). Experience has shown that international cooperation in this area, especially in countries in the region that have similarities in available resources and economic structure, helps regions to specialize more easily and focus on their own competitive advantages in order to create added value. During the Agricultural Fair organized in May 2019, partners from six countries (Italy, Slovenia, Croatia, Greece, Albania and Serbia) working on the project Bio-Economy R.D.I. had a meeting [7].

This project aims to develop a regional innovation system for the Adriatic-Ionian region based on the bioeconomy sector through innovation development. One of its results will be to offer a strategy at the regional and transnational level, which should improve the current situation through the following activities:

- creating a network that will enable intensive collaboration between Adrion region representatives, businesses and academia for joint research, knowledge transfer and skills development
- supporting enterprises and clusters in the process of transition to an industrial model with a higher level of innovation and international cooperation
- strengthening the integration between green chemistry and agri-food clusters in line with the principles of circular economy
- formation of the Adriatic-Ionian market for products based on biological basis
- bridging the gap between existing wide regional inequalities

- activating the process of mutual learning among regions with different levels of bioeconomic business maturity

4. Conclusion

Bioeconomy requires continued and increasing financial support from public sources and the growth of private investment to contribute to greater coherence between national, European and global information and knowledge flows and to bridge institutional and conceptual barriers between researchers, innovators, manufacturers, end-users, policy makers and civil society. Knowledge transfer networks, knowledge and technology brokers, as well as social entrepreneurship, can bridge these gaps. Standards are crucial for the development of labeling of bio-based products, which plays a significant role in their commercialization. It is necessary to provide consumers with clear information on the environmental performance of the products and thus influence their preferential choice. Labels can be crucial for the acceptance of bio-based products by the state and its institutions as a large potential buyer through incentives introduced through the green procurement mechanism.

Bioenergy and a package of policies that support increasing the participation of bioenergy in the future energy mix are an indispensable and extremely significant part of this transformation. This process assures businesses that they can expect to operate in an advanced and integrated market and to identify and offer regional and national policy makers the support they need to design effective policies based on a circular economy and bioeconomy approach.

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UTICAJ PRIMENE TOPLOTNIH PUMPI NA POTROŠNJU PRIMARNE ENERGIJE U SRPSKIM ŠKOLAMA

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Ovaj rad predstavlja deo šireg istraživanja mogućnosti primene toplotnih pumpi u srpskim školama, u kombinaciji sa merama energetske sanacije. On prikazuje studiju slučaja procene operativnih troškova i potrošnje primarne energije za grejanje i hlađenje u nekoliko srpskih škola. Rad razmatra primenu visoko-efikasnih toplotnih pumpi uz daljinsko grejanje, pretpostavljajući troškovno-optimalne režime rada i promenljive cene. Rad pokazuje značaj pristupa procene troškova tokom životnog veka, pažljive alanlize različitih scenarija promene cena i uzimanja u obzir radnih režima sistema za snabdevanje energijom. Toplotne pumpe mogu značajno doprineti uštedi primarne energije i u skoro svim scenarijima predstavljaju poželjniju opciju od daljinskog grejanja.

Ključne reči: *daljinsko grejanje; toplotne pumpe; optimizacija radnih režima; primarna energija; škole*

1. Uvod

Strategija razvoja energetike Republike Srbije [1] propisuje strateške ciljeve u vezi sa sistemima daljinskog grejanja koji uključuju promenu strukture energenata ka većem korišćenju obnovljivih izvora enerije, kao i održivo poslovanje proizvođača toplote. Istovremeno, ova strategija naglašava značaj nastavka promena tržišta električne energije ka daljoj liberalizaciji. Najavljeni prioriteti će verovatno uzrokovati promene i dodatne neizvesnosti u vezi sa cenama daljinskog grejanja i električne energije. Direktive o energetskoj efikasnosti i energetskim performansama zgrada EU [2–5] naglašavaju značaj troškovne efektivnosti mera energetske efikasnsosti [6, 7] i procene na osnovu životnog veka.

Ovaj rad predstavlja deo šireg istraživanja mogućnosti primene toplotnih pumpi u srpskim školama, u kombinaciji sa merama energetske sanacije sa sledećim ciljevima: održavanje sigurnog, održivog i troškovno efektivnog grejanja škola koje nisu priključene na mreže daljinskog grejanja; implementaciju energetski efikasnog i troškovno efektivnog hlađenja u školama; optimizaciju investicija u energetsku sanaciju termičkih omotača škola. On prikazuje studiju slučaja procene operativnih troškova i potrošnje primarne energije za grejanje i hlađenje u nekoliko srpskih škola. Rad prikazuje značaj pristupa procene na osnovu životnog veka, pažljive alanlize različitih scenarija

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promene cena i uzimanja u obzir radnih režima sistema za snabdevanje energijom.

2. Formulacija problema

Ovaj rad ispituje primenu sistema sa toplotnim pumpama sa promenljivim protokom rashladnih fluida (VRF sistemi) u srpskim školama lociranim u urbanim sredinama. Osnovna svrha instalacije VRF sistema je omogućavanje energetski efikasnog i troškovno efektivnog hlađenja u školama. Ipak, ove toplotne pumpe mogu služiti i za grejanje, konkurentno uz sisteme daljinskog grejanja.
Cilj ovog rada je analiza uticaja sistema sa toplotnim pumpama na potrošnju primarne energije, dimenzionisanim na osnovu potrebe za hlađenjem, u školama sa postojećim priključkom na sistem daljinskog grejanja.
Jedna od osnovnih pretpostavki je da će sistemi za snabdevanje energijom raditi u troškovno-optimalnim režimima, uz minimalne operativne troškove, istovremeno potpuno zadovoljavajući potrebe za grejanjem i hlađenjem.
Druga važna pretpostavka je da će se potrebe za grejanjem i hlađenjem ponavljati svake godine, dok će se cene električne energije i daljinskog grejanja menjati. Ovaj rad uzima početni varijabilni deo cene električne energije od 10 cEUR/kWh tokom dana i 2.5 cEUR/kWh noću. Početna vrednost varijabilnog dela cene toplotne energije je 5 cEUR/kWh. Projektovana godišnja povećanja cene električne energije su 1%, 5% i 10%, dok su povećanja cene daljinske toplote −1%, 2% i 5%. Ove vrednosti definišu ukupno devet razmatranih scenarija. Deseti scenario je osnovni koji podrazumeva grejanje iz daljinskih sistema i hlađenje nisko-efikasnim split-sistemima. Značaj razmatranja različitih cenovnih scenarija je prikazan u ref. [8].
Takođe se pretpostavlja da će sve razmatrane škole pre ugradnje toplotnih pumpi biti energetski sanirane postavljanjem izolacije od kamene mineralne vune debljine 15 cm na zidovima i zamenom prozora novim, energetski efikasnim sa ramovima od polivinil hlorida.

3. Metodologija

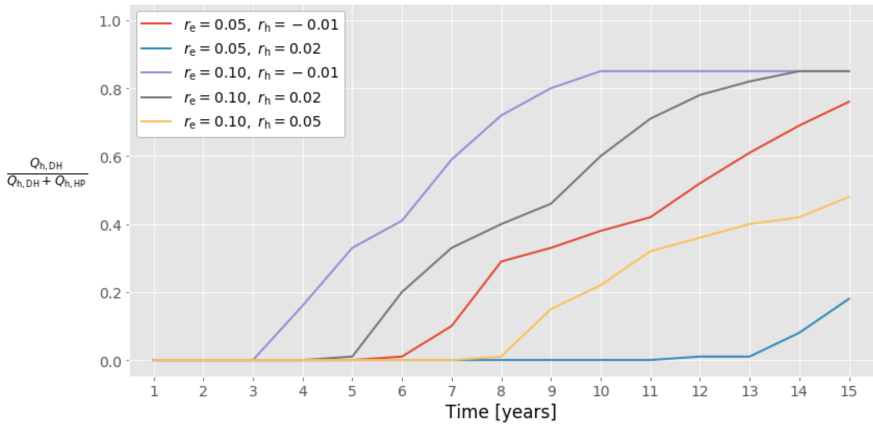
Časovne potrebe za grejanjem i hlađenjem za tipičnu meteorološku godinu određene su korišćenjem programa za energetske simulacije zgrada EnergyPlus [9].
Toplotne pumpe su dimenzionisane prema potrebama za hlađenjem. Potrošnja električne energije toplotnih pumpi je određena uzimajući u obzir stvarne performanse, dobijene od proizvođača, pre svega zavisnost kapaciteta ikoeficijenata grejanja i hlađenja od unutrašnje i spoljšnje temperature. Troškovno-optimalni režimi rada sistema za grejanje sa toplotnim pumpama i vezom sa sistemima daljinskog grejanja su određeni jednostavnim i brzim modelima linearnog programiranja baziranim na vremenskoj dekompoziciji.
Potrošnja primarne energije se računa pomoću konverzionih faktora iz ref. [10]: 2.5 kWh/kWh za električnu energiju i 1.8 kWh/kWh za daljinsku toplotu.

4. Rezultati i diskusija

Rezultati su slični za sve škole i prikazuju da je u većini scenarija grejanje toplotnim pumpama poželjnije sa energetskog i sa troškovnog aspekta, posebno tokom prvih nekoliko godina analiziranog perioda, kada su cene električne energije relativno niske u svim scenarijima. Još jedan važan faktor je visoka efikasnost VRF sistema i relativno visok faktor primarne energije za daljinsku toplotu.

Slika 1 pokazuje relativni udeo toplote iz sistema daljinskog grejanja za različite scenarije za jednu školu. Ne iznenađuje to što je najpovoljniji scenario za dealjinsko grejanje onaj sa najbržim porastom cene električne energije (r_e=10%) i najsporijim porastom cene daljinskog grejanja (r_h=−1%). Kako prva vrednost opada, a druga raste, tako udeo daljinske toplote opada. Konačno, slika 1 ne pokazuje one scenarije u kojima se za grejanje koriste samo toplotne pumpe. U svakom slučaju, postoji više scenarija u kojima se radni režimi — posledično i potrošnja primarne energije i troškovi — značajno menjaju iz godine u godinu sa promenom cena energenata.

Tabela 1 prikazuje potrošnju i uštedu primarne energije u odnosu na osnovni scenario za sve analizirane škole locirane u Nišu. VRF sistemi doprinose smanjenju potrošnje primarne energije za sve analizirane škole, u svim posmatranim scenarijima. Ušteda primarne energije se postiže povećanjem efikasnosti rashladnih mašina, kao i primenom toplotnih pumpi za grejanje. Manje vrednosti opsega potrošnje primarne energije i veće vrednosti ušetede odgovaraju scenarijima sa bržim rastom cene daljinskog grejanja i sporijim rastom cene električne energije i obrnuto. To ukazuje na poželjnost toplotnih pumpi u odnosu na daljinsko grejanje.



Slika 1. Udeo toplote iz sistema daljinskog grejanja za različite scenarije

Tabela 1. Rezime potrošnje primarne energije za analizirane škole u Nišu

Naziv škole	Primarna energija za osnovni scenario [MWh]	Opseg vrednosti primarne energije [MWh]	Opseg vrednosti uštede primarne energije
Učitelj Tasa	3395.56	1339.46–2334.57	31.25%–60.55%
Ratko Vukićević	3083.95	1250.37–2092.63	32.14%–59.46%
Car Konstantin	3698.74	1472.50–2574.43	30.40%–60.19%
Dositej Obradović	2323.96	909.37–1618.59	30.35%–60.87%
Branko Miljković	4044.71	1592.68–2818.06	30.33%–60.62%
Ćele Kula	3043.77	1206.95–2123.93	30.22%–60.35%
Sveti Sava	5803.82	2303.88–4070.19	29.87%–60.30%
Sreten Mladenović Mika	1938.79	750.34–1341.45	30.81%–61.30%
Dušan Radović	10182.65	4473.57–7445.45	26.88%–56.07%

5. Zaključak

Ovaj rad prikazuje studiju slučaja procene operativnih troškova i potrošnje primarne energije za grejanje i hlađenje srpskih škola. Istraživanje razmatra troškovno-optimalan rad visoko-efikasnih toplotnih pumpi kombinovanih sa daljinskim grejanjem i nekoliko scenarija promene cena energenata. Rad ilustruje značaj pristupa procene na osnovu životnog veka i razmatranja radnih režima energetskih sistema. Sa promenom cena energenata, menjaju se i optimalni radni režmi, uzrokujući nekada značajne promene operativnih troškova i potrošnje primarne energije.

Ovo istraživanje ukazuje na mogućnost da sistemi sa topltonim pumpama postanu poželjnija opcija od daljinskog grejanja u Srbiji. Da bi se zadržala postojeća i dalje uvećavala pokrivenost Srbije daljinksim sistemima grejanja, kao i da bi se ispunili strateški ciljevi iz ref. [1], centralne i lokalne vlasti u Srbiji moraju da implementiraju sveobuhvatne mere modernizacije i stabilizacije sektora daljinskog grejanja.

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IMPACT OF HEAT PUMPS APPLICATIONS TO PRIMARY ENERGY CONSUMPTION IN SERBIAN SCHOOLS

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This paper is a part of the wider research related to the possibilities of the application of heat pumps in Serbian schools, in combination with the energy retrofit measures. It presents a case study of the assessment of operation costs and primary energy consumption for heating and cooling several Serbian schools. The paper considers the application of high-efficiency heat pumps in together with district heating under cost-optimal regimes and varying prices. It shows the importance of the life-cycle cost assessment approach, careful analysis of different price-change scenarios, and consideration of energy systems operating regimes. Heat pumps might contribute significantly to primary energy savings and in almost all scenarios represent a preferable option compared to district heating.

Key words: *District Heating; Heat Pumps; Operation Optimization; Primary Energy; Schools*

1. Introduction

The Energy Sector Development Strategy of the Republic of Serbia (ESDS) [1] prescribes the strategic goals related to the district heating (DH) systems that include the changes in the structure of the energy commodities used towards higher utilization of renewable energy sources, as well as the sustainable business operation of heat producers. At the same time, ESDS emphasizes the importance of electricity market development towards further liberalization. The announced priorities are likely to cause the changes and additional uncertainties in the prices of district heat and electricity. The EU directives on energy efficiency and energy performance of buildings [2–5] emphasize the importance of cost-effectiveness of the energy efficiency measures [6, 7] and life-cycle cost assessment.

This paper is a part of the wider research related to the possibilities of the application of heat pumps in Serbian schools in combination with the energy retrofit measures with the aims of: enabling secure, sustainable, and cost-effective heating to the schools not connected to DH networks; implementing energy-efficient and cost-effective cooling in all schools; and optimizing the investments into the retrofit of the thermal envelopes of schools. It presents a case study of the assessment of operation costs and primary energy (PE) consumption (PEC) for heating and cooling several Serbian schools. It illustrates the importance of the life-cycle cost assessment approach, careful analysis of different

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price-change scenarios, and consideration of energy systems operating regimes.

2. Problem Formulation

This paper examines the application of variable refrigerant flow (VRF) heat pump (HP) systems in the Serbian schools located in urban areas. The main purpose of the VRF HP systems installation is enabling energy-eficient and cost-effective refrigeration in schools. However, once HPs are installed, they can serve for heating as well, concurrently with DH supply.

The objective of this paper is analyzing how HP systems in district-heated schools, that are sized for cooling, can impact PEC during the economic lifetime of 15 years.

One of the main assumptions is that the energy supply systems are operated in the cost-optimal manner, thus minimizing the operation cost while fully satisfying the heating and cooling demands.

The other important assumption is that the heating and cooling demands are going to repeat in each year, while the prices of electricity and district heat are going to vary. This paper assumes the starting variable part of electricity price of 10 cEUR/kWh during daytime and 2.5 cEUR/kWh during nights. The starting DH variable part of the price is 5 cEUR/kWh. The projected annual increase rates for the electricity price are 1%, 5%, and 10%, while the rates for the DH price are −1%, 2%, and 5%. These rates define the total of nine considered scenarios. The 10th scenario is the baseline scenario that assumes heating with district heat and cooling with low-efficiency split systems. The importance of taking different costs rates into account is illustrated in Ref. [8].

It is also presumed that all considered schools are the subject of thermal envelope energy retrofit prior to the installation of HPs having the insulation made of 15 cm thick stone mineral wool and energy efficient polyvinyl chloride windows.

3. Methodology

The hourly heating and cooling demands for a typical meteorological year are calculated with the EnergyPlus building energy simulation software [9].

HP systems are sized according to the design cooling demands. The electricity consumption of HP systems is calculated taking into account the realistic manufacturer-provided HP performance characteristics, especially the variation of the capacity, coefficient of performance, and energy efficiency ratio on the indoor and outdoor temperatures. The cost-optimal operation modes of the heating systems that consist of DH and HPs are determined with the simple and fast linear programming optimization models based on time decomposition.

PEC is calculated using PE conversion factors from Ref. [10]: 2.5 kWh/kWh for electricity and 1.8 kWh/kWh for district heat.

4. Results and Discussion

The results are similar for all schools. They show that for most scenarios HP-based heating is preferable from both PE and costs aspects, especially during a few years at the beginning of the analyzed horizon when the price of the electricity is relatively low in all scenarios. Another important factor is high efficiency of VRF systems and relatively high primary energy factor for district heat.

Figure 1 shows the relative share of the heat provided from DH for different scenarios for one school. The most favorable scenario for DH is — not surprisingly — the one where the annual increase rate for electricity price is the highest (r_e=10%), while for DH is the lowest (r_h=−1%). As the former rate decreases and the later increases, the share of DH drops. Finally, Figure 1 does not show the scenarios in which only HPs are used for heating. However, there are several scenarios in which operation regimes — and consequently PEC and operational costs — vary significantly from year to year, with the change of the prices of energy commodities.

Table 1 shows PEC and PEC savings relative to the baseline scenario for all analyzed schools, located in Niš, Serbia. VRF HP systems contribute to PEC reduction for all analyzed schools and in all observed scenarios. PEC savings are achieved both due the increase of refrigeration efficiency and application of HPs for heating. Smaller values of PEC range and higher values of PEC savings range correspond to the scenarios with faster increase of DH price and slower increase of the electricity price, and vice versa. This indicates that such HPs are preferable for lower PEC compared to DH.

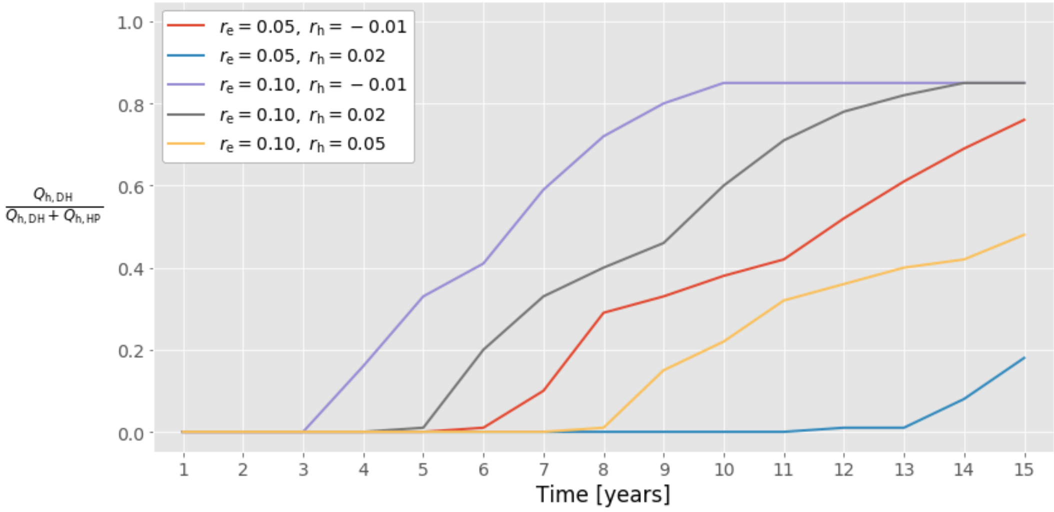

Figure 1. The share of the heat provided from district heating for different scenarios

Table 1. Primary energy consumption summary for analyzed schools in Niš, Serbia

School Name	**PEC for Baseline** [MWh]	**PEC Range** [MWh]	**PEC Savings Range**
Učitelj Tasa	3395.56	1339.46–2334.57	31.25%–60.55%
Ratko Vukićević	3083.95	1250.37–2092.63	32.14%–59.46%
Car Konstantin	3698.74	1472.50–2574.43	30.40%–60.19%
Dositej Obradović	2323.96	909.37–1618.59	30.35%–60.87%
Branko Miljković	4044.71	1592.68–2818.06	30.33%–60.62%
Ćele Kula	3043.77	1206.95–2123.93	30.22%–60.35%
Sveti Sava	5803.82	2303.88–4070.19	29.87%–60.30%
Sreten Mladenović Mika	1938.79	750.34–1341.45	30.81%–61.30%
Dušan Radović	10182.65	4473.57–7445.45	26.88%–56.07%

5. Conclusions

This paper presents a case study of the assessment of operation costs and primary energy consumption for heating and cooling Serbian schools. It considers cost-optimal operation of the energy systems combining heat pumps and district heating under several energy-price scenarios.

The paper illustrates the importance of the life-cycle cost assessment approach and consideration of the operating regimes of energy systems. As the prices of energy commodities vary, the optimal operating regimes change, causing sometimes significant changes in operational cost and primary energy consumption.

This research indicates that the heating systems based the heat pumps of high efficiency might become a preferable option in comparison to district heating in Serbia. To keep existing and increase district heating coverage, as well as to fulfill the strategic goals from Ref. [1], central and local authorities in Serbia have to take comprehensive measures to modernize and stabilize the district heating sector.

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PREDNOSTI UPOTREBE TOPLOTNE PUMPE U KOMORNOJ SUŠARI ZA PEČURKE

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U radu je prikazan primer proračuna jedne konvektivne komorne sušare sa podovima za sušenje pečurki, sa fokusom na upotrebu obnovljivih izvora energije umesto konvencionalnih goriva, pre svega toplotnih pumpi. Digitalizacijom procesa sušenja omogućeno je preciznije i kvalitetnije vođenje procesa, čime je dat veliki doprinos u nastojanju ka energetski efikasnijem i finansijski isplativijem procesu sušenja.

Ključne reči: *sušara; pečurke; toplotna pumpa; automatizacija*

1. UVOD

Sušenje predstavlja jedan od osnovnih načina preradu i čuvanje prehrambenih proizvoda sa visokim sadržajem vlage. Sam proces sušenja zahteva značajnu potrošnju toplotne energije, pa kao takav ostavlja prostora za mnoga poboljšanja na polju energetske efikasnosti. U okviru proračuna komorne sušare, urađen je materijalni i toplotni bilans sušare, odabran je odgovarajući sistem za zagrevanje vazduha i dat je primer moguće regulacije temperature vazduha za sušenje.

2. PRORAČUN KOMORNE SUŠARE ZA PEČURKE

2.1 Materijalni i toplotni bilans sušare

Proračun materijalnog i toplotnog bilansa sušare izvršen je za kapacitet sušare 100 kg vlažnog materijala, za sušenje pečurki vrste šampinjoni (*Agraricus bispourus*). Usvojena početna i krajnja vlažnost pečurki je 90% i 10%, (po vlažnoj osnovi) [1]. Prema jednačinama materijalnog bilansa, za početnu i krajnju vrednost vlažnosti pečurki, količina izdvojene vlage iznosi 88,9 kg, pri čemu se dobija 11,1 kg osušenih pečurki. Toplotnim bilansom sušare određena je količina toplote koju je potrebno dovesti u procesu sušenja. Planirani period rada sušare je u toku cele godine. Predviđeni režim sušenja je sušenje u tankom sloju, sa poprečnim nastrujavanjem zagrejanog vazduha preko vlažnog materijala postavljnog na lese unutar komore za sušenje. Prema preporukama iz [1], temperatura vazduha za sušenje pečurki je 60 °C na ulazu u sušaru i 40 °C na izlazu iz sušare, sa brzinom strujanja od 1 m/s. Sistem je projektovan prema najnižoj prosečnoj jutarnjoj temperaturi u toku godine, koja je prema podacima Republičkog hidrometeorološkog zavoda za mesec januar -7,2 °C, dok je relativna vlažnost vazduha 91%. Potrebna količina vazduha za sušenje je L = 12.058 kg_{sv}, gde su x_1 = 0,00632 $kg_w kg_{sv}^{-1}$ i x_2 = 0,0137 $kg_w kg_{sv}^{-1}$ apsolutne vlažnosti vazduha na ulazu i izlazu iz sušare. Procenjeno vreme trajanja procesa je, prema [1] za proces sušenja pečurki vrste šampinjoni u tankom sloju, na temperaturi od 60 °C i pri brzini strujanja vazduha od 1 m/s, 11 h. Zagrevanje vazduha se vrši u razmenjivaču toplote sa orebrenim cevima. Za predviđene uslove rada i

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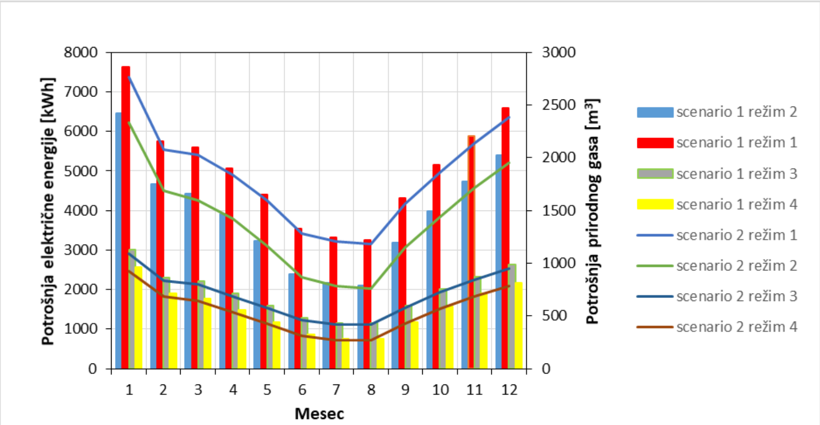
za maksimalni maseni protok vazduha od 0,9 kg/s, potrebna snaga razmenjivača toplote je 61 kW.

3. ANALIZA TROŠKOVA RADA SUŠARE

Predviđeni period rada sušare u toku dana je od 7 h do 18 h, prema procenjenom vremenu trajanja procesa. Za zagrevanje vode u razmenjivaču toplote analizirana su 2 scenarija. Prikazana analiza predviđa poređenje troškova rada scenarija 1. sistema sa toplotnom pumpom zemlja - voda i solarnim kolektorima kao izvorom toplote za zagrevanje vazduha, i scenarija 2. sistema sa kondenzacionim gasnim kotlom i solarnim kolektorima. Oba scenarija su analizirana u 4 različita režima rada: 1. bez rekuperacije otpadnog vazduha i bez regulacije protoka vazduha, 2. sa rekuperacijom otpadnog vazduha i bez regulacije protoka vazduha, 3. bez rekuperacije otpadnog vazduha i sa regulacijom protoka vazduha i 4. sa rekuperacijom otpadnog vazduha i sa regulacijom protoka vazduha, u cilju određivanja potrošnje energenata i troškova rada sušare. Primena toplotnih pumpi u procesima sušenja je veoma česta, ali uglavnom u kondenzacionim sušarama u zatvorenom sistemu cirkulacije vazuduha [2,3,4], za razliku od prikazanog slučaja, u kome je analiziran rad toplotne pumpe u procesu sušenja, ali u otvorenom sistemu sa konstantnim izmenama vazduha. Simulacija rada prikazanih sistema izvršena je u softveru TSol. Za dva navedena scenarija i sva 4 režima rada sušare, maksimalno toplotno opterećenje sistema, pri sušenju jedne šarže pečurki, je u toku januara meseca i iznosi 633 kWh za režim rada 1, dok je najniže maksimalno toplotno opterećenje u režimu 4 i iznosi 207 kWh. Najefikasniji režim rada je 4. u scenariju 1 sa upotrebom toplotne pumpe sa rekuperacijom i regulacijom protoka vazduha. Za taj slučaj, godišnja potrošnja električne energije je 18.070 kWh, čiji su godišnji troškovi 199.651 RSD. Za najpovoljniji režim sistema sa gasnim kotlom, godišnja potrošnja prirodnog gasa je 6531 m^3 i godišnji troškovi prirodnog gasa su 253.161 RSD. Na slici 1. su prikazane potrošnje energenata u toku godine za oba scenarija i u svim režimima rada.



Slika 1. Godišnja potrošnja električne energije i prirodnog gasa

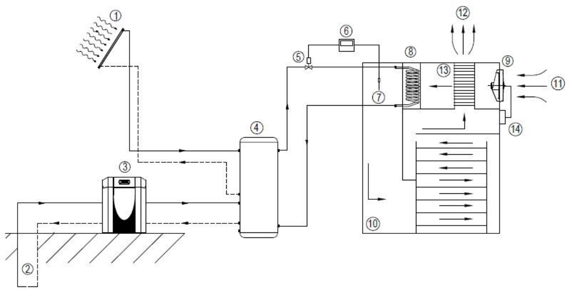
Troškovi su izračunati na osnovu aktuelnih cena električne energije od 5,217 RSD/kWh i 7,826 RSD/kWh u zelenoj i plavoj zoni potrošnje i cene prirodnog gasa od 38,763 RSD/m^3 (sa PDV-om). Troškovi odabranog sistema komorne sušare iznose 3.222.000 RSD ili oko 27.500 €. Nabavka potrebne količine pečurki na godišnjem nivou iznosi 5.110.000 RSD ili približno 43.500 €, za nabavnu cenu od 140 RSD/kg svežih pečuraka. Uz cenu električne energije za rad sistema u toku godine od

199.651 RSD, što je približno 1700 €, ukupni troškovi u prvoj godini rada sušare iznose približno 75.700 €. Sa pretpostavkom da se dnevno osuši jedna šarža svežih pečurki, godišnja proizvodnja iznosi 4051,5 kg suvih pečurki. Sa cenom od 1500 RSD/kg, godišnji prihod od prodaje sušenih pečurki iznosi 6.077.250 RSD ili oko 51.700 €. Iz prikazane analize, period otplate uloženih sredstava je oko 4,5 godina

4. AUTOMATIZACIJA PROCESA SUŠENJA

4.1 Regulacija temperature vazduha

Regulacija temperature vazduha za sušenje omogućena je regulisanjem protoka vode kroz razmenjivač toplote. Promenom stepena otvorenosti ventila kontroliše se količina toplote koja se predaje vazduhu, a na taj način i njegova temperatura. Generalno, regulacija temperature vazduha u sušari se može vršiti različitim metodama: ON/OFF regulacija [5], PI ili PID regulacija [4,6,7], ili u manjem broju slučajeva fazi regulacija (*Fuzzy logic control*) [8]. Na slici 2. je prikazan je analizirana komorna sušara.



Slika 2. Komorna sušara za pečurke sa toplotnom pumpom i solarnim kolektorima

Elementi prikazanog sistema su: 1- solarni kolektori, 2,3 - sistem toplotne pumpe, 4 - akumulacioni rezervoar, 5,6,7 - PID regulator temperature, 8 - razmenjivač toplote, 9 - ventilator, 10 - komorna sušara, 11 - ulaz svežeg vazduha, 12 - izlaz otpadnog vazduha, 13 - rekuperator, 14 - frekventni regulator. Za prikazani slučaj, primena PID regulacije je najpogodnija. ON/OFF regulacija temperature primenu ima uglavnom u sistemima sa električnim grejačima za zagrevanje vazduha i u ovom slučaju ne bi bila odgovarajuća za regulisanje stepena otvorenosti ventila. Primena fazi regulacije uobičajena je u složenijim sistemima gde ima više ulaznih i izlaznih veličina koje treba regulisati, stoga upotreba ove vrste regulacije u datom primeru nije neophodna. Kod PID regulacije, potrebno je definisati procesnu promenljivu koja se reguliše, u ovom slučaju temperatura vazduha na ulazu u sušaru. Željena temperatura vazduha je referentna vrednost u odnosu na koju se definiše odstupanje procesne promenljive. Merenjem ulazne temperature i poređenjem sa referentnom vrednošću, određuje se odstupanje od željene temperature i formira signal greške koji je ulazna veličina za PID kontroler. Na osnovu dobijenog signala greške, PID kontroler generiše upravljački signal koji šalje ka regulacionom ventilu sa aktuatorom. Preko dobijenog signala greške, aktuator reguliše otvorenost regulacionog ventila, i time omogućava održavanje zadate vrednosti temperature na željenom nivou.

4.2 Regulacija protoka vazduha

Regulacijom protoka vazduha u toku procesa postižu se značajna ušteda energije, iz razloga što je u kasnijim periodima trajanja procesa potrebno zagrejati znatno manju količinu vazduha nego na samom početku, kada je izdvajanje vlage najintenzivnije. Potrebne količine vazduha za sušenje su određene na osnovu dobijene brzine sušenja, a na osnovu analiziranja kinetike sušenja i dobijene krive sušenja. Regulaciju protoka je najjednostavnije izvršiti regulacijom brzine obrtanja ventilatora, promenom frekvencije pogonskog elektromotora ventilatora. U sistemu sa regulacijom protoka moguće je uštedeti i do 60 % utrošene energije, dok se u kombinaciji sa rekuperacijom otpadne toplote može postići 70 % uštede, na osnovu prikazane analize rada sistema.

5. ZAKLJUČCI

Na osnovu prikazane analize, može se zaključiti da je primena toplotnih pumpi i u otvorenim sistemima, a ne samo kod kondenzacionih sušara opravdana sa ekonomske tačke gledišta. Primenom odgovarajućih načina regulacije temperature vazduha i njegovog protoka, kao i rekuperacijom otpadnog vazduha omogućena je velika energetska ušteda, čak i do 70 %, u odnosu na slučaj bez rekuperacije i regulacije protoka. Osim toga, upotrebom toplotne pumpe eliminiše se potrošnja fosilnih goriva, i troškovi rada sušare su niži. Period otplate investicije od 4,5 godina je zadovoljavajući, ali se mora naglasiti da je on veoma zavistan od tržišne cene sušenih pečurki.

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ADVANTAGES OF USING HEAT PUMP IN CHAMBER MUSHROOM DRYER

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In this paper is presented calculations example of convective chamber tray dryer for mushroom drying, with aim to usage renewable energy sources instead of conventional fuels, especialy heat pumps. Automatization of drying process is provided more precise and high-quality guidance of process, thus make a great contribution to more efficiency and financially more profitable drying.

Keywords: *Dryer; Mushrooms; Heat Pump; Automatization*

1. INTRODUCTION

Drying process represents one of the most used ways for processing and preservation of food products with high moisture content. Every drying process requires significantly consumption of heat energy, so in that way, leaves many opportunities for improvements of energy efficiency. Within calculations of chamber dryer, material and heat balance is done, convenient system for heating of drying air is selected and example of drying air temperature and flow regulation is given.

2. CALCULATIONS OF MUSHROOM CHAMBER DRYER

2.1 Material and heat balance

Material and heat balance of dryer are done for 100 kg of wet material loading capacity of dryer, for drying of button mushrooms (*Agraricus bispourus*). Initial and final moisture content of button mushrooms are 90 % and 10 % (wet basis). According to material balance equations, for initial and final moisture content of mushrooms, amount of removed moisture is 88.9 kg, whereby it is obtained 11.1 kg of dry mushrooms. Heat balance determine amount of heat required for drying process. Planned work schedule of dryer is all over the year. Predicted drying regime is thin layer drying, with transversely flow of heating air across wet material stacked on dryer chamber trays. According to [1], inlet drying air temperature is 60 °C and outlet drying air temperature is 40 °C, and flow speed of drying air 1 m/s. System is designed according to the lowest annual average morning air temperature, which, accordnig to Republic Hydrometeorological Service of Serbia for january is -7.2 °C, while relative air humidity is 91 %. Required amount of drying air is L = 12 058 kg_{sv}, where x_1=0.00632$kg_w kg_{sv}^{-1}$ and x_2 = 0.0137 $kg_w kg_{sv}^{-1}$ are absolute air humidity on inlet and outlet of drying chamber. Estimate duration of drying process is, according to [1] for thin layer drying of button mushrooms at 60 °C drying air temperature and at flow speed of drying air 1 m/s, 11 hours. Drying air

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is heated in ribbed pipe heat exchanger. For predicted work conditions and maximum mass flow of drying air 0,9 kg/s, required heating power of heat exchanger is 61 kW.

3. DRYERS OPERATIONAL COSTS ANALYSIS

Predicted working period of dryer during day is from 7 A.M. to 6 P.M., according to duration of drying process. Heating water for heat exchanger are analysed in 2 scenarios. Analysis predicts comparation of exploatation costs for scenario 1 - ground to water heat pump in combination with solar collectors sa heat source for drying air heating and scenario 2 - condensing gas boiler in combination with solar collectors. Both scenarios are analysed for 4 different working regimes: 1. without recuperation of waste drying air heat and without drying air flow control, 2. with recuperation of waste drying air heat and without drying air flow control, 3. without recuperation of waste drying air heat and with drying air flow control and 4. with recuperation of waste drying air heat and drying air flow control, to determine energy consumption and operation costs of dryer. Aplications of heat pumps in drying processes are frequently often, but mostley in condesing dryers in closed drying air circulating loop [2-4], unlike this case, in which is analysed heat pump exploatation in open loop of drying air circulation. Work simulation of presented systems are done in TSol software. For both scenarios and all 4 working regimes, maximum system heating load, for drying one batch of mushrooms are 633kWh in January in working regime 1, while the lowest maximum heating load are 207 kWh in January in working regime 4. The most efficient working regime is 4 in scenario 1 with heat pump and recuperation of waste drying air heat and drying air flow control. In that case, annual electricity consumption is 18 070 kWh and annual electricity cost is 199 651 RSD. For the most efficient working regime with condensing gas boiler, annual consumption of natural gas is 6531 m^3 and annual natural gas cost is 253 161 RSD. Fig 1. presents annual consumptions of natural gas and electricity in both scenarios and all working regimes.

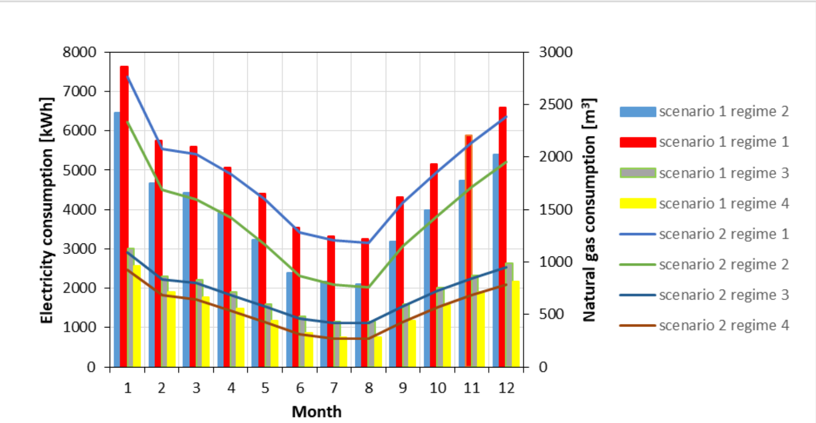

Figure 1. Annual consumption of electricity and natural gas

Costs are determined according to current prices of electricity 5 217 RSD/kWh and 7 826 RSD/kWh in green and blue consumption zone and natural gas 38.763 RSD/m^3 (with VAT). Investment costs of chamber dryer system are approximately 3 222 000 RSD or cca 27 500 €. Annual costs of mushrooms is 5 110 000 RSD or cca 43 500 €, for market price of fresh mushrooms at 140 RSD/kg. With annual costs of electricity 199 651 RSD or cca 1 700 €, total costs in first year of operation are cca 75 700 €.

With assumption of drying one batch fresh mushrooms per day, annual production of dry mushrooms is 4 051.5 kg. With market price of dried mushrooms at 1500 RSD/kg, annual income from selling dried mushroms is 6 077 250 RSD or cca 51 700 €. From shown analysis, payback period is approximately 4.5 years.

4. AUTOMATIZATION OF DRYING PROCESS

4.1 Drying air temperature control

Drying air temperature control is possible to perform by regulating hot water flow in the heat exchanger. By changes in degree of openness of control valve, amount of heat transfered to drying air is controlled, and in that way drying air temperature is controlled too. In general, drying air temperature control can be done by different methods: ON/OFF control [5], PI or PID control [4,6,7], and rarely with Fuzzy control. Fig. 2. presents chamber dryer system which is analysedin thi paper.

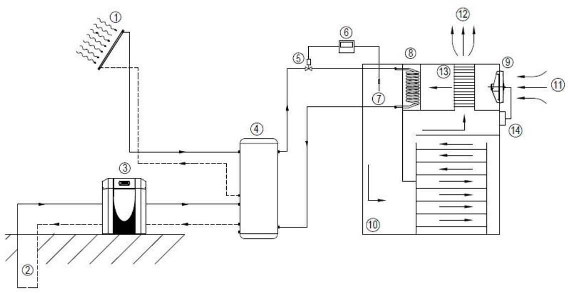

Figure 2. Mushroom chamber dryer with heat pump and solar collectors

Presented system components are: 1 - solar collectors, 2,3 - ground to water heat pump, 4 - buffer tank, 5,6,7 - PID controller system, 8 - heat exchanger, 9 - fan, 10 - chamber dryer, 11 - fresh air inlet, 12 - waste air outlet, 13 - recuperator, 14 - frequent regulator. In presented case, the use of PID control is most suitable. ON/OFF temperature control is mainly applied in systems electric air heaters, and, in this case it would not be appropriate for controlling openness degree of control valve. Fuzzy temperature control is mostly applied in more complex system, with more input and output variables, so use this kind of control is not necessery. In PID control is necessery to define process variable which is controlled, in this case, chamber dryer inlet air temperature. Desired air temperature is referent value of temperature (setpoint) in relation to which deviation of process variable is defined. Measuring drying chamber inlet air temperature and subtracting from referent temperature value gives error signal which is fed to the input of PID controller. Based on error signal, PID controller generates control signal which is fed to control valve with actuator.

4.2 Drying air mass flow control

By regulating the air flow during the process, the significant energy savings could be achieved, due to the fact that much smaller amount of air needs to be heated in the later periods of drying in comparison to the initial drying period (when moisture removal process could be considered as the most intensive). The estimation of needed amount of air is based on drying rate data, which is extracted from the drying curve. The air flow regulation should be carried out by regulating the fan speed (where actually the motor frequency is regulated). With flow regulation, up to 60% of energy could be saved, and up to 70% in combination with heat recuperation, based on the shown analysis.

5. CONCLUSIONS

Based on the showed analysis, it can be concluded that heat pumps usage is economically justified, not just in condensing dryers, but also in open systems. By applying the corresponding regulation principles and the heat recuperation as well, the significant energy saving of 70% could be obtained in comparison with the process without recuperation and air flow regulation. Besides that, heat pump usage eliminates the necessity for fossil fuel combustion, and the operational costs appear to be lower. The payback period of 4.5 years is acceptable, but its dependence on dried mushrooms market price has to be emphasized.

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PREGLED I PREPORUKE RASPOLOŽIVIH TEHNOLOGIJA ZA IMPLEMENTACIJU TELEKOMUNIKACIONOG PODSISTEMA KAO DELA SISTEMA AUTOMATIZACIJE DISTRIBUCIJE

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Rastuće potrebe distributivnih elektro-energetskih sistema (DEES) za proširenjem, funkcionalnim unapređenjem, integracijom i centralizacijom postojećih sistema za automatizaciju distribucije (SCADA, DMS, AMR) i uvođenjem novih sistema (AMI/MDM, Smart Grids, video nadzor i kontrola pristupa i drugi) uslovljavaju proširenje i unapređenje postojećih telekomunikacionih prenosnih puteva u okviru telekomunikacionog (TK) sistema ODS EPS Distribucije na konzumnom području DP Novi Sad.
DEES čini veliki broj elektroenergetskih objekata (EEO) i potrošača električne energije na srednjem i niskom naponu do kojih se moraju obezbediti TK linkovi potrebnog kapaciteta i kvaliteta u skladu sa potrebama navedenih tehnoloških sistema.
Informaciono-komunikacione tehnologije (IKT) daju rešenja za povezivanje poslovnih i tehničkih sistema. Osnovno pitanje jeste uskladiti zahteve korisnika, raspoloživa sredstva i eventualno neka zakonska ograničenja.
Ključne reči: *telekomunikacioni podsistem; automatizacija srednjenaponske distributivne mreže*

1. Uvod

TK infrastruktura ODS EPS Distribucije na konzumnom području DP Novi Sad predstavlja osnovu nad kojom se nadograđuju i implementiraju poslovni i tehnički procesi. Nastajala je postepeno, u skladu sa zahtevima korisnika [1]. Pratile su se raspoložive tehnologije ali i ekonomski aspekti.
TK infrastruktura predstavlja multiservisno orijentisanu arhitekturu namenjenu implementaciji različitih sistema/aplikacija/servisa. Pouzdanost sistema se ogleda i u tome što je sve veći broj sistema u realnom vremenu koji se oslanjaju na nju. Brzine prenosa podatka koje se obezbeđuju zadovoljavaju potrebe servisa koji, po pravilu, imaju velike zahteve za protokom i postoji rezerva za buduća proširenja [2].

2. Korisnički zahtevi za implementaciju TK sistema

Da bi se definisali TK zahtevi, mora se poći od korisničkih/funkcionalnih zahteva pojedinih podsistema za automatizaciju distribucije [2], odnosno moraju se sagledati sledeći implementacioni zahtevi koji su u vezi sa TK potrebama ovih podsistema:

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- Koje su sve vrste i koliki broj objekata/potrošača iz pojedinih klasa objekata koji su uključeni u posmatrani podsistem za automatizaciju distribucije?
- Koliki je obim i potrebna brzina prenosa podataka u okviru posmatranog podsistema za automatizaciju, iskazano u odnosu na smer prenosa (od EEO/potrošača – ka EEO/potrošaču) i u odnosu na različite vrste podataka koje treba preneti za podsistem?
- Koja je minimalna frekvencija osvežavanja podataka potrebna za svaku vrstu podataka u okviru posmatranog podsistema za automatizaciju (za svaki od zahtevanih TK servisa)?
- Kolika su očekivana vremena odziva na pojedine komande koje se izdaju u okviru podsistema za automatizaciju?
- Kolika je procentualna zastupljenost objekata/potrošača u odnosu na vrstu EE mreže (kablovska/nadzemna)?
- Koji je minimalni novo zaštite podataka potreban?
- Koji je dominantni tip naselja (urbani, prigradski, ruralni) u kome se nalaze EEO/potrošači?

Kada se formulišu odgovori na gore navedena pitanja, odnosno, kada se definišu ključni korisnički zahtevi za potrebne TK veze, moguće je definisati okvirne tehničke karakteristike tih veza. Nakon toga je moguće ciljano analizirati sve moguće raspoložive (komercijalno dostupne) TK tehnologije koje bi mogle biti pogodne za implementaciju za određene klase TK veza.

3. Pregled aktuelnih komunikacionih tehnologija

Za svaki segment komunikacionih potreba u DEES moguće je pronaći različite komunikacione tehnologije i TK opremu kojima bi se mogla realizovati zahtevana klasa TK veze sa procenjenim prenosnim kapacitetima [2].

3.1. Sopstveni optički sistemi prenosa

Korišćenje sopstvenih optičkih kablova i sistema prenosa (gde bi troškovi korišćenja bili samo troškovi održavanja opreme i kablova) se nesumnjivo nameću kao najbolje rešenje jer bi prenosni kapaciteti bili praktično neograničeni, tako da bi se mogle zadovoljiti sve sadašnje i buduće TK potrebe u DEES, a pouzdanost na vrlo visokom nivou. Na žalost, ovo rešenje je istovremeno investiciono najskuplje.

3.2. Širokopojasni PTP i PtMP radio sistemi

Osnovna prednost radio sistema u odnosu na kablovske sisteme je jeftinija i brža implementacija, a glavni nedostatak promenljiv kvalitet prenosa zbog promena uslova propagacije radio signala.
Dosadašnja iskustva u korišćenju širokopojasnih PTP i PtMP radio sistema u EPS Distribuciji su u većini slučajeva pozitivna. Ovakvi sistemi su relativno jednostavni za implementaciju i pružaju pouzdanu vezu prilično velikog kapaciteta [3].

3.3. Uskopojasni digitalni radio sistemi

Korišćenje uskopojasnih digitalnih radio sistema za potrebe automatizacije srednjenaponske DEES se po svojim karakteristikama nameće kao najoptimalnije rešenje [4]. Naročito ako se opredelimo za korišćenje radio opreme koja je specijalno dizajnirana za potrebe prenosa podataka (paketni digitalni radio). Prednosti uskopojasnih radio sistema su korišćenje licenciranog frekventnog opsega, velike zone pokrivanja i izbegavanje dodatnih konvertora protokola.

3.4. PLC sistemi

Komunikacija preko EE vodova (Power Line Communications - PLC) omogućava upotrebu elektro mreže za prenos podataka. Osnovna ideja PLC-a je smanjenje operativnih troškova i rashoda za realizaciju novih telekomunikacionih mreža. PLC može da se koristi praktično u svim ravnima EE mreže, visokonaponskoj, srednjenaponskoj i niskonaponskoj.

3.5. GSM/GPRS, 3G i LTE (4G) radio sistemi

Razvoj i omasovljenje GSM mreža kao i povećanje kapaciteta i pouzdanosti učinilo je da korišćenje ovih servisa javne mobilne mreže bude dosta jednostavno i efikasno. Međutim, komercijalni karakter ove mreže predstavlja ozbiljan nedostatak o kom se mora voditi računa kada se ide na masovnu i raznovrsnu primenu ovog rešenja za realizaciju nekih tehnoloških podsistema DEES.
U posledenje vreme trend u svetu je izgradnja malih sopstvenih 4G (LTE - LongTerm Evolution) sistema na nekom od licenciranih opsega i ovo je svakako jedna od tehnologija koja bi mogla naći široku primenu u automatizaciji DEES.

3.6. Javni KDS sistemi

Javni KDS sistemi sada već predstavljaju vrlo ozbiljnu alternativu za TK povezivanje SN/NN EEO (eventualno i klase SN EEO) pa čak i klasa SN i NN potrošača, posebno u gradovima i drugim većim naseljima.

4. Izbor odgovarajuće komunikacione tehnologije

Na osnovu iskustva iz do sada implementiranih TK podsistema za potrebe automatizacije DEES, kao i na osnovu izvršene analize rešenja koja se nude na našem tržištu, procena je da bi optimalno rešenje za realizaciju TK podsistema za potrebe automatizacije srednjenaponskog DEES trebalo da bude jedna od TK tehnologija navedenih u prethodnom poglavlju (u nekim slučajevima i kombinacija dve ili više navedenih tehnologija).
U Tabeli 1 su navedene glavne prednosti i mane nekoliko komunikacionih tehnika koje nalaze svoju primenu u okviru automatizacije srednjenaponskog DEES.

Tabela 1 - Komunikacione tehnologije za „inteligentne“ distributivne mreže

Tehnologija	Prednosti	Nedostaci
Optika	• Veliki kapacitet • Stabilne karakteristike	• Cena

Bežična	• Isplativa • Brza instalacija • Razvijena tehnologija	• Ograničeno pokrivanje • Kapacitet • Bezbednost • problemi sa ishodovanjem dozvola za odgovarajuće frekventne opsege
PLC	• Obimna pokrivenost • Isplativa • Dostupna infrastruktura	• Slabljenje signala • Visok nivo šuma • EMI • još uvek slaba ponuda opreme na teritoriji Srbije
LTE (4G)	• Veliki kapacitet • Brza instalacija	• problemi sa ishodovanjem dozvola za odgovarajuće frekventne opsege • još uvek slaba ponuda opreme na teritoriji Srbije

5. Zaključak

U ovom radu su prikazani pojedini elementi TK infrastrukture ODS EPS Distribucije na konzumnom području DP Novi Sad namenjene za automatizaciju DEES-a. Pre svega cilj je bio je da se ukaže da je pravilno projektovanje i odabir opreme u okviru TK podsistema veoma važan za pouzdano i kvalitetno funkcionisanje čitavog sistema za automatizaciju DEES.

Za pravilan odabir opreme u okviru TK podsistema neophodna je saradnja stručnih lica iz više oblasti, kako bi se na osnovu precizno definisanih potreba i parametara navedenih u poglavlju 2 izabrala odgovarajuća TK oprema. Potrebno je birati rešenja koja na prvom mestu obezbeđuju dovoljnu pouzdanost i bezbednost podataka, kao i odgovarajuće TK prenosne kapacitete za prenos podataka. Poželjno je da se što više unificira oprema koja se koristi u okviru TK podsistema za potrebe automatizacije DEES na konzumnom području DP Novi Sad (pa i na nivou čitave Srbije).

Pri izgradnji i razvoju TK infrastrukture treba voditi računa ne samo o tome da se zadovolje trenutne potrebe nego da se mreža gradi imajući u vidu projektovane kapacitete i servise u narednom planskom periodu.

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OVERVIEW AND RECOMMENDATIONS OF AVAILABLE TECHNOLOGIES FOR IMPLEMENTATION OF THE TELECOMMUNICATION SUBSYSTEM AS A PART OF THE DISTRIBUTION AUTOMATION SYSTEM

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The growing needs of Power Distribution Systems (DEES) for the expansion, functional enhancement, integration and centralization of existing distribution automation systems (SCADA, DMS, AMR) and the introduction of new systems (AMI / MDM, Smart Grids, video surveillance and access control, and others) require the extension and improvement of the existing telecommunication solutions within the telecommunication (TK) system of the ODS EPS Distribucija in the territory of DP Novi Sad.

DEES consists of a large number of power facilities (EEE) and medium and low voltage power consumers. TK links of the required capacity and quality, in accordance with the needs of the above technological systems must be provided for those consumers.

Information and communication technologies (ICT) provide solutions for connecting business and technical systems. The basic task is to match user requirements, available resources and possibly some legal restrictions.

Keywords: Telecommunication Subsystem; Automation of Medium Voltage Distribution Network

1. Introduction

TK infrastructure of ODS EPS Distribucija in the territory of DP Novi Sad represents basis for upgrading and implementation of business and technical processes. It was developed gradually, in accordance with user requirements [1]. Available technologies and economic aspects were taken into account.

TK infrastructure is multiservice oriented architecture designed to implement different systems/applications/services. System reliability is also reflected in the increasing number of real-time systems that rely on it. The data rates that are provided meet the needs of new services that, as a rule, have high data rate requirements and there is a reserve for future extensions [2].

2. User requirements for implementation of TK system

In order to define TK requirements, one must start with the user/functional requirements of individual distribution automation subsystems [2], *i.e.* the following implementation requirements that relate to the TK needs of these subsystems must be considered:

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- What are all types of objects/consumers that are included in the monitored distribution automation subsystem? What is the number of objects/consumers?
- What is the volume and required data rate within the observed automation subsystem, expressed in relation to direction of transmission and in relation to different types of data to be transmitted for related subsystem?
- What is the minimum refresh data rate required for each type of data within the monitored automation subsystem?
- What are the expected response times for individual commands issued within the automation subsystem?
- What is the percentage of facilities/consumers in relation to the type of electric network (cable/overhead)?
- What minimum level of data protection is required?
- What is the dominant type of settlement (urban, suburban and rural) in which substations/consumers are located?

When answering the above questions and defining key user requirements for the required TK links, it is possible to define technical characteristics of those links. It is welcome to target all available (commercially available) TK technologies that may be suitable for the implementation of certain classes of TK connections.

3. An overview of current communication technologies

For each segment of communication in DEES it is possible to find different communication technologies and equipment that could implement the required class of connections with the estimated capacity and data rate [2].

3.1. Self-owned fiber optic transmission systems

Use of self-owned fiber optic cables and transmission systems (where the cost of use would be only the cost of maintaining equipment and cables) are undoubtedly the best solution because transmission capacities would be practically unlimited so that all current and future communications needs in DEES can be met. In this case reliability is at very high level. Unfortunately, this solution is most expensive investment at the same time.

3.2. Broadband PTP and PtMP radio systems

Main advantage of radio systems over cable systems is cheaper and faster implementation, and the main disadvantage is variable transmission quality due to propagation of radio signals.

Experience in using Broadband PTP and PtMP radio systems in EPS Distribucija is in most cases positive. Such systems are relatively easy to implement, they provide a reliable connection and quite high capacity [3].

3.3. Narrowband digital radio systems

Use of narrowband digital radio systems for the automation of medium voltage DEES is by its characteristics the most optimal solution [4]. Especially if we choose to use radio equipment that is specially designed for data transmission purposes (packet data radio).

Advantages of narrowband radio systems with packet data radio are usage of a licensed frequency band, large coverage areas and avoidance of additional protocol converters.

3.4. PLC systems

Power Line Communications (PLC) enables use of an electrical network for data transmission. The basic idea of PLC is to reduce operating costs and expenses when implementing new telecommunications networks. PLC can be used in all levels of EE network, high voltage, medium voltage and low voltage.

3.5. GSM / GPRS, 3G and LTE (4G) radio systems

The development and expansion of GSM networks as well as increase of capacity and reliability have made usage of these public mobile network services quite simple and efficient. However, commercial character of this networks is a serious drawback that must be taken into account when it comes to massive and varied implementation of this solutions for implementation of some DEES subsystems.
Recently, trend in the world is to build small proprietary 4G (LTE – Long Term Evolution) systems on one of licensed bands and this is certainly one of the technologies that could find wide application in DEES automation.

3.6. Public cable systems

Public cable systems are very serious option for connecting MV/LV substations and even some HV substations, especially in cities and other major settlements.

4. Choosing the right communication technology

Based on the experience from previously implemented TK subsystems for the purposes of DEES automation, as well as based on the performed analysis of the solutions offered in our market, it is estimated that the optimal solution for implementation of communications subsystems for the purposes of automation of medium voltage DEES should be one of TK technologies mentioned in the previous chapter (in some cases a combination of two or more of the technologies listed).
The table outlines the main advantages and disadvantages of several communication technologies that are applicable within medium voltage DEES automation.

Table 1 - Communication technologies for "intelligent" distribution network

Technology	Advantages	Disadvantages
Fiber optic	• Large capacity • Stable performance	• Price
Wireless	• Cost effective • Quick installation	• Limited coverage • Lower capacity and security • Issues with obtaining licenses for the appropriate frequency bands
PLC	• Extensive coverage • Cost effective • Available	• Signal attenuation • High noise level • Still poor supply of equipment in the territory of

	infrastructure	Serbia
LTE (4G)	• Large capacity • Quick installation	• Issues with obtaining licenses for the appropriate frequency bands • Still poor supply of equipment in the territory of Serbia

5. Conclusion

This paper presents some elements of TK infrastructure of ODS EPS Distribucija in the territory of DP Novi Sad. First of all, the goal was to show that the proper design and selection of equipment within the TK subsystem is very important for the reliable and high-quality functioning of entire DEES automation system.

Proper selection of equipment within TK subsystem requires cooperation of experts from multiple fields in order to select the appropriate communications equipment based on the precisely defined parameters listed in Chapter 2. It is necessary to choose solutions that, in the first place, provide sufficient data reliability and security, as well as adequate data rate.

It is good to unify (as much as possible) the equipment used within TK subsystem for the purposes of DEES automation in the territory of DP Novi Sad (even in the territory of Serbia).

In the construction and development of the TK infrastructure, we should take care not only to meet current needs, but to build the network in view of projected capacities and services in the next planning period.

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ISKUSTVO U RADU SA SOLARNIM ELEKTRANAMA
BEZBEDNOST KOMUNIKACIJA

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Mogućnost udaljenog praćenja rada malih solarnih elektrana doprinosi efikasnijem radu timova i nižim troškovima, dok sa druge strane zahteva primenu mera zaštite računarskih mreža i obučenost osoblja u pogledu poznavanja pretnji prilikom pristupa i kontroli rada elektrane na daljinu. U radu se prikazuju osnovne sajber pretnje za energetske uređaje koji su dostupni na mreži, kao i preporučene metode zaštite udaljenog pristupa uređajima.

Ključne reči: *monitoring energetskih sistema; udaljeni monitoring; IoT; bezbednost komunikacija; solarne*

1. Uvod

Tokom proteklih nekoliko godina, brzo rastuće korišćenje mrežnih rešenja za udaljeni pristup energetskim postrojenjima predstavlja najveći izazov za zaštitu okruženja koje postaje sve više digitalno. Prema Symantec izveštaju o ugroženosti interneta od 2016. godine, postoji povećanje ciljanih napada od 125% u odnosu na prethodnu godinu [1]. Energetski uređaji kao jedna vrsta internet stvari (IoT) predstavljaju relativno nov izazov za bezbednost, dok su elektro distribucije posebno izložene rizicima od IoT hakovanja [2]. Bez efektivne zaštite u primeni, tokovi informacija kroz digitalne mreže mogu biti manipulisani preko sajber napada, uključujući različite kvarove i ispade, pa do izazivanja oštećenja opreme i ugrožavanja života [3]. Kao jednu od mera za zaštitu od pretnji za energetske sisteme iz sajber prostora, Ministarstvo energetike SAD je nedavno formiralo kancelariju za sajber bezbednost, bezbednost energije i hitne odgovore, sa finansiranjem od 96 miliona evra.

Dok mogućnosti mobilnih uređaja i udaljenog praćenja rada malih elektrana doprinosi efikasnijem radu radnih timova i smanjenju troškova, osiguranje njihove zaštite je takođe kritično.

2. Prednosti udaljenog pristupa sistemu

U pogledu privilegija koje korisnici mogu imati u korišćenjem udaljenog pristupa energetskim uređajima, najčešće postoje dve grupe korisnika: 1) osnovni korisnici i 2) privilegovani korisnici. Osnovnim korisnicima se omogućuje samo uvid u praćenje rada sistema. Ova grupa korisnika dobija prava pristupa sistemu koja se označavaju kao „read only“.

Praćenje rada fotonaponskih generatora energije udaljenim pristupom donosi brojne prednosti. Udaljeni pristup sistemu osnovnim korisnicima omogućuje: Nadgledanje trenutnih parametara

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sistema; Praćenje ponašanja sistema u realnom vremenu, Analizu profila proizvodnje i korišćenja energije; Praćenje istorije rada u prethodnom periodu ; Pregled alarma.

Privilegovani korisnici, ili administratori, pored omogućenog praćenja rada sistema na taj način, imaju omogućen pristup podešavanjima pomoću konzole za udaljeni pristup, Ovim putem direktnim pristupamo na gateway. U takvom režimu rada, administratori na konzoli mogu da: izvrše daljinsku dijagnostiku kvara sistema: izvrše izmene određenih podešavanja; daljinsko uključivanje i isključivanje uređaja. Da bi ovakav način rada bio omogućen, podešavanje na gateway uređaju treba da bude takvo da je omogućen udaljeni pristup sa konzolom. Ukoliko nije taj slučaj, gateway će samo slati podatke na server povezan sa portalom, dok pristup sa konzolom za udaljeni pristup neće biti moguć. Izmene koje se mogu obavljati na takav način svakako da mogu da izazovu i nepravilan rad uređaja, pa čak i ozbiljan kvar uređaja. Da bi se to sprečilo, proizvođači uređaja koje je moguće konfigurisati na takav način zahtevaju da lokalni partneri za servis uređaja prođu kroz odgovarajuću obuku, pre nego što im dodele prava da mogu biti napredni korisnici ili administratori sa pravima udaljenog pristupa uređajima.

3. Pretnje kod udaljenog pristupa energetskim uređajima

Kao što je navedeno u uvodnom poglavlju, energetski uređaji koji se nalaze na mreži mogu biti izloženi mogućnosti različitim vrstama sajber napada. To je jedan od osnovnih razloga zbog čega se Scada sistemi i danas čuvaju u izolovanom okruženju, bez korišćenja internet protokola. Ako se imaju u vidu moguće ranjivosti koje po svojoj prirodi mogu da čine zastaleri operativni sistem, na kome je softver koji kontroliše rad uređaja, gde nije moguće jednostavno preći na noviji verziju i ažurirati najnovije zakrpe sa anti-virusnim definicijama. 2) nedostatak enkripcije komunikacionih kanala omogućuje da se komunikacija presretne i preuzmu kredencijali za prijavljivanje na sistem 3) nedovoljni mehanizmi zaštite na PLC uređajima, svakako da potpuna izolacija takvog sistema predstavlja najsigurniju zaštitu.

Na osnovu ranijeg istraživanja autora [5], primeri najčešćih sajber pretnji koje mogu da kompromituju rad energetskih uređaja na mreži navedeni su na tabeli 1. Može se reći da je koncept sajber napada takav da se želi pristupiti samom uređaju, na primer otkrivanjem korisničkog imena i lozinke za pristup, Pri tome, zlonamerni napadi sa spoljne mreže biće bolje eksploatisani i iskorišćeni, ukoliko ostanu nedetektovani od strane odbrane organizacije, sve dok cilj napadača nije postignut. Što duže upad u sistem ostane neprimećen, pretnja će lukavije biti iskorišćena [6].

Tabela 1: Pretnje od sajber napada sistema kod energetskih uređaja

Br.	Pretnja	Opis pretnje	Pogođeni resursi	Mere i sistemi zaštite
01	Virus-Malver	Malver je softver napravljen da naruši ili inficira računarski sistem.	Sistemski softver Sajt (php fajlovi) Podaci na serverima	• Upravljanje izmenama; • Kontrole protiv zloćudnih softvera ; • Postupci za kontrolu izmena na sistemu

02	Phishing	Ugroženi su svi podaci kojima je moguć pristup spolja	Pristupna lozinka za autentikaciju Pristupna lozinka za VPN	• Politika upravljanja lozinkama • Pristup sa obezbeđene mreže i lokacije • Multifaktorska autentikacija (npr. pomoću tokena)
03	Ransom-ware	Ransomware je vrsta malvera koji pokreće enkriptovanje i zaključavanje svih fajlova kojima korisnik ima pristup. Oporavak se omogućuje uz plaćanje.	Podaci na računaru Deljeni fajlovi na serveru Baze podataka	• Provera e-mail adrese pošiljaoca mejla i neotvaranje priloga i linkova iz mejla • Izrada rezervnih kopija informacija • Čuvanje podataka na izolovanoj lokaciji
04	Napad na servise (DoS Attack)	Pokušava da onesposobi mrežu, računar ili neki drugi deo infrastrukture na taj način da ih korisnici ne mogu koristiti; napad na ranjive delove mreže; zakrčenje propusnog opsega; preplavljivanje vezama	Sajt Webmail Firewall	• Sajt da bude distribuiran preko više servera • Redundantnost uređaja • Bezbednost mrežnih usluga • Monitoring logova
05	Botnet napad (Botnet Attack)	Botnet je određeni broj povezanih zaraženih uređaja na internetu, koji se koriste da obavljaju različite zadatke. Organizator koristi botnet distribuirani napad, npr. slanje velikih količina neželjene elektronske pošte (eng. SPAM).	Sajt Server za sajt Firewall	• Politika upravljanja lozinkama • Bezbednost mrežnih usluga • Monitoring logova • Redundantnost uređaja
06	Hijacking	Vrsta napada u kojoj napadač kontroliše komunikaciju dve strane, lažno se predstavljajući kao druga strana	Firewall Mrežni uređaji Energetski uređaji	• Politika upravljanja lozinkama • Bezbednost mrežnih usluga • Monitoring logova • Enkripcija saobraćaja • Provera verodostojnosti izvora
07	Brute Force	Metod pokušaja i greške otkrivanja informacija o lozinki ili PIN za pristup sistemu, korišćenjem automatizovanih softvera	Firewall Mrežni uređaji Energetski uređaji	• Složene lozinke • Zaključavanje naloga nakon više uzastopnih pogrešnih pokušaja • Multifaktorska autentikacija
08	Zero Day Attack	Napad koji koristi poznatu ranjivost istog dana kada je ranjivost postaje opšte poznata. Malver koristi ranjivost pre nego što je zakrpa napravljena.	Firewall Serveri Računari Energetski uređaji	• Alati za praćenje ponašanja • Ažurna izdanja i poslednje verzije softvera • Praćenje incidenata na sajtovima
09	Upad u saobraćaj	Iskorišćenjem pogrešne konfiguracije	Firewall Serveri Energetski uređaji	• Firewall uređaj i podešavanja • Enkripcija saobračaja • IDS (Intrustion Detection Systems) • SIEM • Data analytics- - machine learning

4. Mogući pristupi zaštite sistema

Primer bezbednosne kontrole koja je široko prihvaćena kao osnova za kritičnu infrastrukturu je princip bezbednosnog zoniranja. Uspostavljena je najbolja praksa da infrastruktura komunalne komunikacije treba sigurno da bude odvojena od spoljnih mreža (kao što su Internet ili povezane mreže poslovnih partnera), obično pomoću demilitarizovane zone (DMZ) između internih i eksternih mreža. Tu se podrazumeva dodatni zaštitni zid (firewall) za otkrivanje pokušaja upada u zaštićenu zonu, uključujući tačku ulazne logičke komunikacije na udaljenoj podstanici..

Za praćenje rada osnovnih korisnika obezbeđuje se portal i postojanje vebservera sa bazom samo za očitavanje podataka. Podaci sa fizičkog uređaja se šalju na webserver. Za privilegovane korisnike, kod promene parametara dodatna zaštita je promena položaja mikroprekidača na uređaju.

U pogledu sprečavanja ulaska u sistem otkrivanjem lozinke, preporučuje se multifaktorska autentikacija. To podrazumeva da se pored korisničkog imena i lozinke, zahtevaju pin dobijen preko mobilonog telefona ili tokena, kao dodatne mere autentifikacije. Ovakva rešenja zavise od proizvođača samog uređaja- U najboljem slučaju primenjuje se kriptografija za sve kritične komunikacije da osigura poverljivost komunikacije i podršku virtuelnom razdvajanju mreža, autentikaciju strana koje komuniciraju i integritet podataka u tranzitu [2].

Ostale mere uključuju mrežne protokole koji podržavaju enkripciju, bezbednost aplikacija, segmentaciju mreže, nagledanje sistema, odgovore na incidente i blagovremeno otklanjanje uočenih ranjivosti [7].

5. Zaključak

Omogućen pristup energetskim uređajima preko spoljne mreže, udaljenim pristupom pomoću računara ili mobilnog telefona omogućuje efikasniji rad i niže troškove. Komfor rada na konzoli za udaljeni pristup međutim zahteva ozbiljne mere zaštite koja podrazumeva zaštićenu mrežu u odnosu na mrežno okruženje, pouzdane metode autentikacije i primenu mera najboljih praksi od strane privilegovanih korisnika, koji trebaju biti svesni mogućih propusta izazvanih slabim merama zaštite energetskih uređaja

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EXPERIENCES IN REMOTE MANAGEMENT OF SOLAR POWER PLANTS - COMMUNICATIONS SECURITY

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The possibility of remote monitoring of the operation of small solar power plants contributes to more efficient team work and lower costs, while on the other hand requires the application of computer network security measures and staff training in the knowledge of threats when accessing and controlling the operation of the power plant at a distance. The paper presents basic cyber threats for power devices that are available online, as well as recommended methods for protecting remote access to devices.

Key words: Energy Systems Monitoring, Remote Monitoring, IoT, Communication Security, Solar

1. Introduction

Over the past few years, the rapidly growing use of computer network solutions for remote access to energy plants has been the biggest challenge for protecting the plants in an increasingly digital environment. According to the Symantec Internet Threat Report of 2016, there is a 125% increase in targeted attacks over the previous year [1]. Power devices as one type of the Internet of Things (IoT) devices, pose a relatively new security challenge, while power utilities are particularly at risk of IoT hacking [2]. Without effective protection deployment, information flows through digital networks can be manipulated through cyber-attacks, including various failures and outages, to cause damage to equipment and endanger lives [3]. As one of the cyber-security threats to energy systems, the US Department of Energy recently established an office for cybersecurity, energy security and emergency response, with funding of € 96 million.

While the capabilities of mobile devices and remote monitoring of the operation of small power plants contribute to the more efficient work of teams and reduces monitoring and diagnostics costs, ensuring their protection is also critical.

In terms of the privileges that users may have in using remote access to energy devices, there are usually two groups of users: 1) basic users and 2) privileged users. Basic users are usually only allowed to see the system work, with granted system access rights, which are referred to as read only.

Monitoring the operation of photovoltaic energy generators by remote access has many benefits. Remote access to the system enables basic users to: monitor current system parameters, real-time monitoring of system behaviour, analysis of production and profile of energy use, monitoring of work history in the previous period, alarm overview.

2 Advantages of remote access to energy systems

Privileged users, or administrators, in addition to enabled system monitoring in this way, have

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access to the settings using the remote access console. This is a direct access to the gateway. In this mode, console administrators can: remotely diagnose system failures: make changes to specific settings; remotely switch the device on and off. For this mode to be enabled, the setting on the gateway device should be such that remote access with the console is enabled. If not, the gateway will only send data to the server connected to the portal, while access with the remote access console will not be possible. Changes that can be made in this way can certainly cause the device to malfunction and even cause extensive device malfunction. To prevent this, device manufacturers that can be configured in this way require local device service partners to undergo appropriate training before being granted the rights to be advanced users or administrators with remote device access rights.

3. Threats on remote access to power devices

This is one of the main reasons why Scada systems are still stored in an isolated environment today without using Internet protocols. Considering the possible vulnerabilities inherent in the operating system, on which the software controlling the device is running, if it is not possible to simply upgrade to the latest version and update the latest patches with anti-virus definitions, vulnerability is born. The second vulnerability is the lack of encryption of communication channels which allows the communication to be intercepted. The third vulnerability is the insufficient protection mechanism on PLC devices. Naturally, that complete isolation of a such system represents the safest protection.

Table 1. Types of cyber threats relevant for energy devices

No.	Threat	Description	Affected resources	Protection measures
01.	Malware	"**Malware**" is short for "malicious software" - **computer** programs designed to infiltrate and damage **computers** without the user consent.	Software Websites (php files) Server Data VPN / IT Router	• Tracking changes • Malware Control • Steps for change control on the system
02.	Phishing	Fraudulent attempt to obtain sensitive information such as usernames, passwords and credit card details by disguising as a trustworthy entity in an electronic communication.	Login password VPN password	• Password management • Access from secure location • Multifactor authentication
03.	Ransomware	**Ransomware** is a type of malicious software from crypto-virology that threatens to publish the victim's data or perpetually block access to it unless a ransom is paid.	Computer data Shared files on server Data base	• Secure email address • Backup • Data storage on isolated, secure location
04.	Crypto-jacking	Unauthorized use of someone else's computer to mine cryptocurrency	Webservers Browser Mobile phone	• Server patch • End-point security solutions • Scanning for crypto-mining indicator
05.	DoS Attack	Cyber-**attack** in which the perpetrator seeks to make a machine or network resource unavailable to its intended users by temporarily or indefinitely	Website Webmail Firewall	• Website distribution on several servers • Device redundancy • Network security • Firewall management

		disrupting services of a host on Internet.		• Logo monitoring
06.	Botnet Attack	**Botnets** can be used to perform distributed denial-of-service **attack** (DDoS **attack**), steal data, send spam, and allows the attacker to access the device and its connection.	Website Website server Firewall	• Password policy • Restricted remote access • Network security • Firewall monitoring • Logo monitoring
07.	Hijacking	Network security **attack** in which the attacker takes control of a communication between two entities and masquerades as one of them.	Firewall Network devices Electrical devices	• Password policy • Network security • Logo monitoring • Traffic encryption
08.	Brute Force	Method to gain access to a site or server with various combinations of usernames and passwords again	Firewall Network devices IoT devices	• Complicated passwords • Locking account after m ultiple attempts to login • Multifactor authenticati on
09.	Zero Day Attack	Undisclosed computer-software vulnerability that hackers can exploit to adversely affect computer programs, data, additional computers or a network	Firewall Servers Computers IoT devices	• Tracking behavior chan ges • Latest and updated soft ware versions • Tracking incidents on w ebsites
10.	Intrusion attack	Using wrong configuration	Firewall Servers IoT devices	• Firewall device and setti ng • Traffic encryption • IDS • SIEM • Data analytics- - machin e

Based on an earlier study by the author [5], examples of common cyber threats that can compromise the operation of power devices online are listed in Table 1. It can be said that the concept of cyber attack is such that it wants to access the device itself, for example by discovering a username and access passwords, to make the device misused online, or to disrupt its normal operation. In doing so, malicious attacks from the outside network will be better exploited and exploited if left undetected by the organization's defences until the attacker's target is reached. The longer the intrusion into the system goes unnoticed, the more cunning the threat will be exploited [6].

4. Additional protection measures

An example of security control that is widely accepted as the basis for critical infrastructure is the principle of security zoning. Best practice has been established that utilities should be securely disconnected from external networks (such as the Internet or connected business partner networks), usually by means of a demilitarized zone (DMZ) between internal and external networks. This includes an additional firewall to detect attempts to break into the protected area, including the point of entry logic communication at a remote substation.

To monitor the work of basic users, a portal and a webserver with a database for read-only data are provided. Data from the physical device is sent to the webserver. For privileged users, when changing

parameters on a device online, the additional protection may be local confirmation required by physically changing the position of the microswitch on the device on site.
Multifactor authentication is recommended for preventing password entry into the system. This implies that, in addition to the username and password, they require a pin obtained through a mobile phone or token as additional authentication measures. Such solutions depend on the manufacturer of the device itself and the software that manages it, so the user is often unable to influence it later.
At best, cryptography is applied to all critical communications to ensure communication confidentiality and support for virtual separation of networks, authentication of communicating parties and data integrity in transit [2].
Other measures include network protocols that support encryption, application security, network segmentation, system monitoring, incident response, and timely elimination of perceived vulnerabilities [7].

5. Conclusion

Enabled access to power devices via an external network, remote access via a PC or mobile phone allows for more efficient operation and lower costs. However, the comfort of working on a remote access console requires serious security measures, including a secure network over the network environment, reliable authentication methods, and the application of best practices by privileged users, who should be aware of the possible failures caused by poor security measures for power devices.

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IZRADA AKCIONOG PLANA ZA PODSTICANjE POVEĆANjA KORIŠĆENjA OBNOVLjIVIH IZVORA ENERGIJE NA TERITORIJI OPŠTINE BAČKA PALANKA

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Cilj projekta (finansiranog od strane Pokrajinskog sekretarijata za regionalni razvoj, međunarodnnu saradnji i lokalni razvoj) je bio doprinos razvoju resursno efikasne lokalne zajednice kroz podsticanje povećanja upotrebe obnovljivih izvora energije (OIE) u ukupnoj potrošnji energije u opštini Bačka Palanka. Dostizanje efikasnosti u korišćenju lokalnih energetskih resursa jedan je od najvažnijih strateških zadataka svake lokalne zajednice. Ovim putem, smanjuje se zavisnost od fosilnih goriva i uvoznih energenata uz istovremeno snažnom dorinosu zaštiti životne sredine. U cilju sagledavanja postojećeg stanja potrošnje energije, i primene OIE izvršeno je snimanje stanja na terenu, obilaskom i anketiranjem odabranih lokalnih aktera. Takođe je izvršeno mapiranje pomencijala obnovljivih izvora energije na merimoriji opšmine Bačka Palank, nakon čeg su, u skladu sa Akcioonim planom za primenu OBP, definisani pririteti i predlozi odgovarajućih projekata.

Ključne reči: *Akcioni plan; Obnovljivi izvori energijei; Snimanje postojećeg stanja; Mapiranje potencijala; Lokalna zajednica.*

1. Uvod

U dokumentut Strategija održivog razvoja opštine Bačka Palanka za vremenski period od 2014. do 2020. godine [1] date su, u posebnom poglavlju, karakteristike i analiza stanja energetike i energetske infrastrukture na teritoriji Optštine. U dokumentu je dat i odgovarajući akcioni plan. Akcioni plan razrađuje prioritete, mere i predlaže projekte koji su u direktnoj ili indirektnoj vezi sa predmetnim Akcionim planom za podsticaje povećanja korišćenja obnovljivih izvora energije na teritoriji opštine Bačka Palanka i koji se može posmatrati kao njegov prirodni nastavak i detaljnija razrada i operacionalizacija jednog programskog segmenta. Od oblasti, obuvaćenih Strategijom, pimena OIE provlači se, direktno ili indirektno, u sledeća četiri poglavlja: INFRASTR UKTURA I URBANIZAM, ZAŠTITA ŽIVOTNE SREDINE, POLjOPRIVREDA I RURALNI RAZVOJ i TURIZAM. U ovim poglavljima, od navedenih prioritwta, identiffikovani sau prioriteti vezani za primenu OIE. Za ove priorittete predloženi su odgovarajući odgovarajući prioritei i projekti u naredne 3 (tri) godine.

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2. Snimak postojećeg stanja

U cilju sagledavanja postojećeg stanja u pogledu potrošnje energije, i primene OIE izvršeno je snimanje stanja na terenu, obilaskom i anketiranjem odabranih lokalnih aktera. Anketom su oobuhvaćeni: ustanove i objekti javne namene (7), komunalna preduzeća (3), privredni subjekti (2), poljoprivredna gazdinstva (2) i civilni sektor. Upiitnik je obuhavatio 6 grupa pitanja: (1) Potrošnja energije (Toplotne i Električne), (2) Dosadašnje mere za smanjivanje potrošnje energije, (3) Dosadašnji primenjeni OIE, (4) Planirane mere za smanjivanje potrošnje energije, (5) Planirane mere za primenu OIE i (6), Redosled prve 3 mere u rešavanju energetskih problema.

Rezultati sprovedene ankete su sledeći: (2) Preuzete mere za smanjivanje potrošnje – skoro kod svih (3) Primenjeni OIE - primenjeni u manjoj meri (4) Plnirane mere za smanjivanju potrošnje energije - kod svih i (5) Planirane mere za primenu za primenu OIE - skoro kod svih. Rezultai anketiranja pokazuju da je po potrošnji toplotne energije: 7 objekata nalazi u razredu "G" i 2 objekta u razredu "D". Prelaskom ovih objekata u razred "C", pod pretpostavkom da se svi greju na prirodni gas sa cenomom od 40 RSD/m^3, ukupna ušteda iznosila bi 8.500.000 RSD.

3. Mapiranje potencijala OIE

Mapiranjem, na teritoriji Opštine, obuhvaćeni su sledeći OIE (1) BIOMASA Potencijali agrarne biomase i Biogas potencijal stočnog fonda, (2) Solarna energija, (3) Geotermalna energija i (4) Primena toplotnih pumpi Pri definisanju potencijala žetvenih ostataka OBP, korišćeni su podaci Studije APV [2], **Studija o proceni ukupnih potencijala i mogućnostima proizvodnje i korišćenja biogasa na teritoriji AP Vojvodine** [3], razmatrani su potencijal za proizvodnju biogasa od eksktremenata životinja. Istta metodolgija je korišćena je pri proceni biogas potencijala Opštine. Osnov za procenu solarnog potencijala bila je **Studija o proceni ukupnog solarnog potencijala - solarni atlasi mogućnosti "proizvodnje" i korišćenja solarne energije na teritoriji APVojvodine** [4]. Geotermalni potencijal procenjen je na bazi podataka iz **Studije Geotermalni atlas Vojvodine** [5] finasiran od strane APVojvodine.

Tabela 1. Procenjeni ukupni potencijal OIE Opštine Bačka Palanka

OIE	ktoe	MWh	Mm^3_{PG}
Žetveni ostaci	27,86	323.989	36,42
biogas	0,93	11.044	1,24
Solarna energija	3,93	45.724	5,14
Ukupno	32,74	380.757	42,80

Na osnovu istraživanja, konstatuje se da je objekat podoban za primenu toplotnih pumpi i upotrebu OIE ako specifično projektno toplotno opterećenje grejanja objekta ne prelazi 50W/m^2. Ovom vrednošću specifičnog projektnog toplotnog opterećenja grejanja q_H[W/m^2] obezbeđeno je da se objekat može grejati niskotemperaturnom instalacijom (najpovoljnija podna), i da polazna voda od toplotne pumpe prema kućnoj instalaciji grejanja ne prelazi 40°C [6].

4. Definisanje prioriteta

Od svih prioriteta datih u Strategiji [1] identifikovani oni veyani za primenu OIE. Makon identifikacije prioriteta vezanih za primewnu OIE, izabrani su prioriteti u naredne 3 godine. U Tabeli 2 dati su primeri prioriteta.

Tabela 2. Primeri definisanje prioriтeтa u naredne 3 godine

<table>
<tr><td rowspan="4">1</td><td colspan="3">INFRASTRUKTURA I URBANIZAM</td></tr>
<tr><td>Prioritet</td><td>Cilj</td><td>Mera</td></tr>
<tr><td rowspan="2">PRIVREDNA INFRASTRUKTURA – ENERGETSKA INFRASTRUKTURA</td><td rowspan="2">Razvoj alternativnih izvora energije i obezbeđenje energetske efikasnosti</td><td>Razvoj alternativnih izvora energije</td></tr>
<tr><td>Obezbeđenje energetske efikasnosti izgradnje</td></tr>
<tr><td rowspan="3">2</td><td colspan="3">ZAŠTITA ŽIVOTNE SREDINE</td></tr>
<tr><td>Priooritet</td><td>Cilj</td><td>Mera</td></tr>
<tr><td>ZDRAVIJI, KVALITETNIJI I BEZBEDNIJI ŽIVOTNI PROSTOR OPŠTINE BAČKA PALANKA</td><td>Poboljšanje kvaliteta ambijentalnog vazduha.</td><td>Smanjenje aerozagađenja (upotrebe fosilnih goriva u grejanju, paljenja lisne mase, saobraćaja u centru naselja).</td></tr>
<tr><td rowspan="4">3</td><td colspan="3">POLjOPRIVREDA I RURALNI RAZVOJ</td></tr>
<tr><td>Priooritet</td><td>Cilj</td><td>Mera</td></tr>
<tr><td>ODRŽIVI PRIVREDNI RAST</td><td>Jačanje konkurentnosti agrarnog sektora na domaćem i inostranom tržištu</td><td>Razvoj ruralne ekonomije sa fokusom na poljoprivrednu proizvodnju</td></tr>
<tr><td></td><td>Diversifikacija ekonomskih aktivnosti na selu</td><td>Podrška razvoju nepoljoprivrednih delatnosti na poljoprivrednim gazdinstvima</td></tr>
</table>

Za realizacija prioriteta i odgovarajućih mera predloženi su odgovarajući projekti. Primer jednog predloženog projekta dat je u nastavku.

Oblast **INFRASTRUKTURA I URBANIZAM**
Prioritet Privredna infrastruktura – energetska infrastruktura
Mera Obezbeđenje energetske efikasnosti izgradnje
Projekat
ANALIZA POTENCIJALA ZA ENERGETSKU SANACIJU ODABRANIH JAVNIH OBJEKATA NA TERITORIJI OPŠTINE BAČKA PALANKA

Cilj Projekta je Izrada analize stanja izabranih javnih objekate, definisanje uslova uspešnog EPC (Energy Permorance Contracting) projekta i priprema uslova za pilot tendersku proceduru EPC za izbor ESCO kompanije. Projektom bi bilo obuhvaćeno nekoliko većih i manjih objekata javne namene / ustanova, čiji se troškovi potrošnje energije, energenata i vode izmiruju iz budžeta jedinice lokalne samouprave

5. Zaključak

Ovaj Projekat ima svoje prirodno utemeljenje u „Strategija održivog razvoja opštine Bačka Palanka za vremenski period od 2014. do 2020. godine". U cilju realizacije Akcionog plana datog u pomenutoj Strategiji vezanih za primenu OIE na teritoriji Opština Bačka Palanka izabrani, u skladu sa Predlogom Projekta, su odgovorajući prioriteti. Izabrane prioritete slede odgovarajući ciljevi i mere. Konkretizacija ovih mera predviđeno je realizacijom predlženih projekata odosno aktivnosti.

Reference

[1] Službeni glasnik RS", br. 25/2013

[2] Martinov, M.(editor), Višković, M., Bojić, S., Dumnić, B., Golub, M., Krstić,J. **Studija prostornog razmeštaja namenskih javnih skladišta agrarne biomase na teritoriji AP Vojvodine**, Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine, Novi Sad, 2016

[3] Martinov, M , Đatkov Đ., Krstić, J., Vujić, G., Tešić, M., Dragutinović, G., Golub, M., Bojić, S., Brkić, M., Ogrizović, B. **Studija o proceni ukupnih potencijala i mogućnostima proizvodnje i korišćenja biogasa na teritoriji APVojvodine**, Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine Novi Sad, 2011

[4] Lambić , M., Pavlović, P., Tolmač, T., Pavlović, M., Prvulović, S., Pavlović i N., Pekez, J **Studija o proceni ukupnog solarnog potencijala - solarni atlasi mogućnosti "proizvodnje" i korišćenja solarne energije na teritoriji AP Vojvodine**, Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine Novi Sad, 2011.

[5] Martinović, M., Zlokolica Mandić, M., Vukićević. Z. Geotermalni atlas Vojvodine, Pokrajinski Sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine, Beograd-Novi Sad, 2010.

[6] Ченејац, А., Бјелаковић, Р., Петровић, П. и Ченејац, М., **Студија о могућностима примене топлотних пумпи на територији АП Војводине, како за индивидуалне и комерцијалне објекте појединачно, тако и за даљинске системе грејања по угледу на ЕУ, а у складу са актуелном ЕУ директивом** Покрајински Секретаријат за енергетику и минералне сировине Аутономне покрајине Војводине, Нови Сад, 2012.

Projekat, sufinansiran od strane Pokrajinskog sekretarijata za regionalni razvoj, regionalnu saradnju i l okalnu samoupravau, Ugovor br. 141-016-14/2018-03-8, je realizovala Opština Bačka Palanka.

DEVELOPMENT OF AN ACTION PLAN AIM TO INCREASE THE USE OF THE RENEWABLE ENERGY SOURCES ON THE TERRITORY OF THE BAČKA PALANKA MUNICIPALITY

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[1] Association „Cluster for Energy Efficiency“, Novi Sad, Serbia
[2] Bačka Palanka municipality, Bačka Palanka, Serbia
[3] Vojvodina Guarantee Fund, Novi Sad, Serbia

The aim of the project (funded by the Provincial Secretariat for Regional Development, International Cooperation and Local Development) was to contribute to the development of a resource efficient local community by encouraging an increase the use of renewable energy sources (RES) energy in the municipality of Backa Palanka. Achieving efficiency in the use of local energy resources is one of the most important strategic tasks of each local community. In this way, dependence on fossil fuels and imported energy resources is reduced. At the same time the contribution to environmental protection is significant. In order to screen the current state of energy consumption and the implementation of RES, a survey of the situation on the ground was made, by visiting and interviewing selected local actors. The potential of renewable energy sources was mapped on the territory of Backa Palanka municipality, after which, in accordance with the Municipality Action Plan for the implementation of the RES, the priorities as well as appropriate proposals of the projects were defined.

Key words: *Action Plan; Renewable Energy; Current State Screening; Potential Mapping; Local Community*

6. Introduction

The document on the Sustainable Development Strategy of the Municipality of Backa Palanka for the period from 2014 to 2020 [1] provides, in a separate chapter, the characteristics and analysis of the state of energy and energy infrastructure in the territory of the Municipality. The document also provides an appropriate Action Plan. The Action Plan elaborates priorities, measures and proposes projects. The Action Plan covers also issues related, directly or indirectly, related to increase the use of renewable energy sources in the territory of Backa Palanka municipality, which can be seen as more detailed elaboration and operationalization of the accepted program segment. Of the areas covered by the Strategy, RES is addressed, directly or indirectly, in the following four chapters: INFRASTR CULTURE AND URBANISM, ENVIRONMENTAL PROTECTION, AGRICULTURE AND RURAL DEVELOPMENT and TOURISM. In these chapters, of the indicated priorities, the priorities related to the implementation of RES are identified. For the next 3 years appropriate priorities and projects are proposed.

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7. Current state screening

In order to screen the current situation in terms of energy consumption, and the implementation of RES, a survey was carried out of the situation on the ground, by visiting and interviewing selected local actors. The survey included: public institutions (7), utility companies (3), business entities (2), agricultural holdings (2) and the civil sector. The questionnaire included 6 groups of questions: (1) Energy consumption (Thermal and Electrical), (2) Applied measures to reduce energy consumption, (3) Applied RES so far, (4) Planned measures to reduce energy consumption (5) Planned RES application and (6). Indicate the first 3 priority measures in solving your energy problems.

The results of the survey are as follows: (2) Applied measures to reduce energy consumption - almost all (3) Applied RES so far - applied to a lesser extent (4) Planned measures to reduce energy consumption - all (5) Planned RES application - almost all. The results of the survey show that in terms of thermal energy consumption: 7 objects are in class “G” and 2 objects are in class “D”. Moving these facilities to “C” class, assuming that they are all heated with natural gas at a price of 40 RSD / m^3, the total savings would be 8,500,000 RSD.

8. RES potential mapping

Mapping, within the territory of the Municipality, covers the following RES (1) BIOMASS Agricultural biomass potentials and Livestock biogas potential, (2) Solar energy, (3) Geothermal energy and (4) Heat pumps application. In defining the potential for harvesting residues of the Municipalty the correspomding APV Study data was used [2]. **The study on the estimation of the total potentials and possibilities of biogas production and utilization in the territory of AP Vojvodina** [3], considered the potential for production of biogas from animal extracts. The same methodology was used in assessing the biogas potential of the Municipality. The basis for the assessment of solar potential was the **Study on the assessment of total solar potential - solar atlases of the possibility of "production" and use of solar energy in the territory of APVojvodina** [4]. Geothermal potential was estimated on the basis of data from the **Study of the Geothermal Atlas of Vojvodina** [5] financed by APVojvodina.

Table 1. Estimated total RES potential of Backa Palanka Municipality

RES	ktoe	MWh	$Mm^3_{NATURAL\ GAS}$
Harvest residues	27,86	323.989	36,42
biogas	0,93	11.044	1,24
Solar energy	3,93	45.724	5,14
Total	32,74	380.757	42,80

Based on the research, it can be concluded that the facility is suitable for the application of heat pumps and the use of RES if the specific design heat load of the facility's heating does not exceed 50W / m^2. This value of the specific design heat load q_H [W / m^2] ensures that the facility can be heated by a low-temperature installation (the most favorable floor), and that the supply water from the heat pump to the home heating installation does not exceed 40 ° C [6].

9. Priorities definition

Of all the priorities given in the Strategy [1] the priorites relevant for the implementation of RES was identificated. After identifying all priorities related to the RES application, priorities planned to be aplicated in the next 3 years have been selected. Table 2 gives examples of yhe selected priorities.

Tabela 2. Examples of the selected priorities in the next 3 years

1	**INFRASTRUCTURE AND URBANISM**		
	Priority	**Goal**	**Measure**
	ECONOMIC INFRASTRUCTURE - ENERGY INFRASTRUCTURE	Development of alternative energy sources and provision of energy efficiency	Development of alternative energy sources
			Ensuring energy efficiency of construction
2	**ENVIRONMENTAL PROTECTION**		
	Priority	**Goal**	**Measure**
	A HEALTHIER, BETTER QUALITY AND SAFER LIVING SPACE IN THE MUNICIPALITY OF BACKA PALANKA	Improvement of ambient air quality	Reduction of air pollution (use of fossil fuels in heating, burning of leaf mass, traffic in the center of the settlement).
3	**AGRICULTURE AND RURAL DEVELOPMENT**		
	Priority	**Goal**	**Measure**
	SUSTAINABLE ECONOMIC GROWTH	Strengthening the competitiveness of the agricultural sector in the domestic and foreign markets	Development of a rural economy with a focus on agricultural production
		Diversification rural economic activities	Support for the development of non-agricultural activities on agricultural holdings

In order to realize indicated priorities and appropriate measures corresponding projects have been proposed. An example of such project is given below.

Area **INFRASTRUCTURE AND URBANISM**
Priority Economic infrastructure - energy infrastructure
Measure Ensuring energy efficiency of construction
Project **ANALYSIS OF THE POTENTIAL FOR ENERGY ANATION OF SELECTED PUBLIC FACILITIES ON THE TERRITORY OF BAČKA PALANKA MUNICIPALITY**

The aim of the project is to create an analysis of the condition of selected public facilities, in order to define the conditions of a successful EPC (Energy Permorance Contracting) project and to prepare the conditions for an EPC pilot tender procedure for the selection of an ESCO company. The project would cover several larger and smaller public buildings / institutions whose energy and water consumption costs are covered by the budget of the local government unit.

10. **Conclusion**

This Project has its foundation in the Document "Sustainable Development Strategy of Backa Palanka Municipality for the period 2014-2020". In order to implement the Action Plan given in the aforementioned Strategy related to the implementation of RES in the territory of the Municipality of Backa Palanka, the selected priorities, in accordance with the Project Proposal, the corresponding priorities have been identificated. The selected priorities are followed by appropriate goals and measures. The concreteization of these measures is foreseen by the implementation of the proposed projects.

References

[1] Službeni glasnik RS", br. 25/2013 (in Serbian)

[2] Martinov, M. (Editor), Višković, M., Bojić, S., Dumnić, B., Golub, M., Krstić, J. *Studija prostornog razmeštaja namenskih javnih skladišta agrarne biomase na teritoriji AP Vojvodine,* Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine, Novi Sad, 2016 (in Serbian)

[3] Martinov, M , Đatkov Đ., Krstić, J., Vujić, G., Tešić, M., Dragutinović, G., Golub, M., Bojić, S., Brkić, M., Ogrizović, B. *Studija o proceni ukupnih potencijala i mogućnostima proizvodnje i korišćenja biogasa na teritoriji APVojvodine***,** Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine Novi Sad, 2011 (in Serbian)

[4] Lambić , M., Pavlović, P., Tolmač, T., Pavlović, M., Prvulović, S., Pavlović i N., Pekez, J *Studija o proceni ukupnog solarnog potencijala - solarni atlasi mogućnosti "proizvodnje" i korišćenja solarne energije na teritoriji APVojvodine***,** Pokrajinski sekretarijat za energetiku i mineralne sirovine Autonomne pokrajine Vojvodine Novi Sad, 2011 (in Serbian)

[5] Martinović, M., Zlokolica Mandić, M., Vukićević. Z., *Geotermalni atlas Vojvodine*, Pokrajinski Sekretarijat zaenergetiku i mineralne sirovineAutonomne pokrajine Vojvodine Beograd-Novi Sad, 2010 (in Serbian)

[6] Čenejac, A., Bjelaković, R., Petrović, P., Čenejac, M., *Studija o mogućnostima primene toplotnih pumpi na teritoriji AP Vojvodine, kako za individualne i komercijalne objekte pojedinačno, tako i za daljinske sisteme grejanja po ugledu na EU, a u skaldu sa aktuelnom EU direktivom*, Pokrajinski Sekretarijat za energetiku i mineralne sirovine AP Vojvodine, Novi Sad, 2012 (in Serbian)

Project, co-financed by the Provincial Secretariat for Regional Development, Regional Cooperation and Local Self-Government, Contract no. 141-016-14 / 2018-03-8, and was implemented by the Municipality of Backa Palanka.

PRIMENA INDUSTRIJSKIH AMONIJAČNIH TOPLOTNIH PUMPI U PROIZVODNJI SLADA

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[c] Emerson Commercial & Residental Solutions-Vilter, Beograd, Srbija

Ovaj rad predstavlja prikaz sveobuhvatnog rešenja koje podrazumeva ugradnju toplotne pumpe u tehnološkom procesu dobijanja slada. Cilj ugradnje toplotne pumpe je pre svega finansiski efekat od uštede prirodnog gasa koji se koristi u procesu sušenja slada. Pored toga, ovo rešenje ima i uticaj na smanjenje efekata staklene bašte koga izaziva sagorevanje fosilnih goriva. Na osnovu projektnog zadatka dobijenog od strane investitora, data je šema idejnog rešenja na osnovu koje je razrađena detaljna tehnološka šema ugradnje toplotne pumpe. Karakteristično za ovakav tip tehnološkog procesa je da u određenim periodima može da se istovremeno koristi toplota hlađenja (koja predstavlja izvor toplote za toplotnu pumpu) i toplota kondenzacije koja se koristi u tehnološkom procesu za dogrevanje svežeg vazduha. U periodu kada je ovo moguće SOR sistema je preko 6. U ovom slučaju je izabrana amonijačna toplotna pumpa proizvođača SAMIFI. Izmenjivači toplote u rekuperatoru i na otpadnom vazduhu su izabrani tako da zadovoljavaju sve zahteve projektnog zadatka. U krugu hlađenja slada i napojne vode su pločasti izmenjivači. Na osnovu proračuna sistema a prema karakteristikama proizvođača, sračunati su COP sistema, koji su garantovani od strane izvođača radova Tehnomag-Teco. Na osnovu garantovanih COP sistema data je analiza očekivanih ušteda prirodnog gasa tj. povrat ulaganja u investiciju toplotne pumpe.

Ključne reči: *industrijske amonijačne toplotne pumpe; proizvodnja slada; ušteda potrošnje prirodnog gasa; obnovljivi izvori energije; zaštita čovekove okoline*

1. Uvod

Industrijske toplotne pumpe koje se kategorišu kao obnovljivi izvori energije i koje doprinose zaštiti čovekove okoline i smanjenju efekta stakelene bašte kroz smanjenje emisije CO_2 u atmosferu, kao i povećanju efikasnosti-smanjenju troškova proizvodnje, sa amonijakom kao prirodnim rashladnim fluidom, predstavljaju tehničko rešenje koje je u izuzetnoj ekspanziji širom sveta [1-2]. Ukoliko se ove toplotne pumpe koriste u procesima gde je moguće osim efekta grejanja iskoristiti i efekat hlađenja onda njihova efikasnost nema premca.

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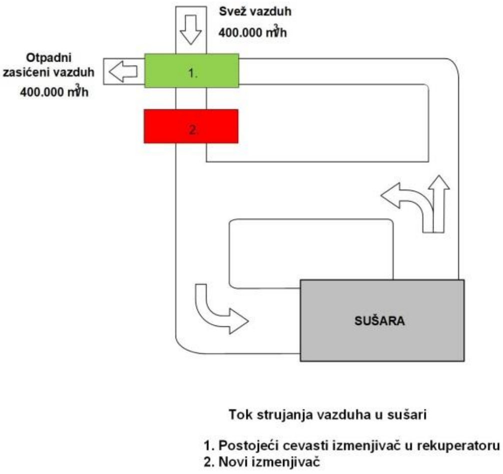
U tom smislu, korporacija iz Francuske SUFFLET koja je najveći evropski pa i svetski proizvođač slada za pivarsku industriju , u nekoliko svojih sladara ugradila je toplotne pumpe radi smanjenja potrošnje prirodnog gasa u procesu sušenja slada. Kao najoptimanlnije tehničko rešenje za svoju sladaru Maltinex u Srbiji izabrano je rešenje firme Tehnomag-Teco iz Novog Sada.

Tokom procesa sušenja slada jedan deo vazduha (u ovom slučaju 400.000 m3/h) se odbacuje, tzv. otpadni vazduh, u cilju smanjenja sadržaja vlage u vazduhu na ulasku u sušaru. U istoj količini se ubacuje svež vazduh, slika 1. Prvo zagrevanje prisisanog vazduha je u cevastim izmenjivačima, gde se sveži vazduh zagreva strujom otpadnog vazduha na slici označenim 1. Ideja je da se dodatno povećanje temperature svežeg vazduha pre ulaska u sušaru izvrši izmenjivačima toplote označenim 2 (Slika 1)



Slika 1 Šema toka vazduha u sušari

2. Metodologija i rezultati

2.1 Projektni zadatak

Sa ovim ciljem postavljen je projektni zadatak od strane investitora da se ponudi toplotna pumpa sa sledećim projektnim parametrima: Grejna snaga oko 2 MW., Protok vazduha 400.000 m^3/h, Max. temperatura otpadnog vazduha nakon staklenih izmenjivača 34^{0}C, Min. temperatura otpadnog vazduha nakon staklenih izmenjivača 18^{0}C (Temperatura vode za hlađenje 6-9^{0}C), Tempertura vode na izlasku iz kondenzatora letnji period, prelazni period, zimski period 55/50/45^{0}C, Zahtev za izmenjivače toplote, Izmenjivači za zagrevanje vazduha, Blok izmenjivača Cu/Al, Razmak lamela > 5mm, Debljina lamela 0,35 mm, Debljina zida cevi>0.8 mm, redni raspored, Izmenjivači za korišćenje otpadne toplote:, Blok izmenjivača Prohrom/AlMg, Razmak lamela 10mm., Debljina lamela min. 0,35 mm i Debljina zida cevi 0,4mm.

Tabela 1. Tabelarni prikaz projektnih parametara

Radni uslovi	Ext1°C	Ext20°C	Ext37°C
Temparatura isparavanja	**+3,0°C**	+6,0°C	+3,3°C
Temperatura kondenzacije	**+46°C**	+51°C	+56°C
Economajzer	yes	yes	yes
Broj obrtaja elektromotora	2950 rpm	2750 rpm	3150 rpm
Rashladni kapacitet	1514 kW	1519 kW	1409 kW
Absorbovana snaga	338,6 kW	350,4 kW	406,3 kW
Toplota kondenzacije	1848 kW	1865 kW	1815 kW
Hlađeni fluid	MEG 30%	MEG30%	MEG 30%
Ulazna temperatura	+10°C	+12,9°C	+10°C
Izlazna temperatura	+6°C	+9°C	+6°C
Zapreminski protok	351 m^3/h	358 m^3/h	327 m^3/h
Kapacitet	1514 kW	1519 kW	1409 kW

Tabela 1. Tabelarni prikaz projektnih parametara (nastavak)

Radni uslovi	Ext1°C	Ext20°C	Ext37°C
Grejani fluid	MEG 30%	MEG30%	MEG30%
Ulazna temperatura	+35°C	+40°C	+46,7°C
Izlazna temperatura	+45°C	+50°C	+55°C
Zapreminski protok	172 m^3/h	173 m^3/h	206 m^3/h
Kapacitet	1848 kW	1865 kW	1815 kW

Pošto sušara sladare radi preko cele godine, na osnovu projektnog zadatka su proračunati radni parametri sistema toplotne pumpe za tri perioda: zimski, prelazni i letnji. Na osnovu proračunatog COP sistema data je garancija na kvalitet posla i garantovanost COP sistema od strane glavnog izvođača radova firme Tehnomag -Teco.

2.2 Tehničko rešenje

Osnovni izvor toplote koji je stalno na raspolaganju je toplota otpadnog vazduha koja se izmeni u izmenjivačima toplote [3-4]. Značajan izvor toplote koji je na raspolaganju u letnjem periodu je toplota dobijena od hlađenja ječma prilikom klijanja u klijalištima a razmenjena u pločastom izmenjivaču Manje značajan izvor toplote koji se takođe koristi je toplota hlađenja vode za močilišta (gde se natapa ječam pre klijanja).

Toplota dobijena na strani kondenzatora toplotne pumpe se predaje svežem vazduhu u izmenjivačima Sekundarni nosilac toplotne energije sa strane isparivača i kondenzatoraje TP 30% rastvor voda-etilenglikol. U cilju dobijanja toplotne energije na kondenzatoru TP, deklarisane za određeni vremenski period, potrebno je imati dovoljno toplotno opterećenje na isparivaču. Ovo se postiže održavanjem temperature smeše na izlazu iz isparivača, promenom broja obrtaja elektromotora cirkulacione pumpe u krugu otpadnog vazduha i cirkulacion epumpe u krugu za hlađenje u klijalištima.

Kontrola rada TP i cirkulacionih pumpi u primarnom krugu isparivača i krugu kondenzatora 100/210 vrši se putem PLC-a TP. Kontrola rada celokupnog sistema vrši se sistemskim PLC-om. Obračun predate toplotne energije svežem vazduhu vrši se putem kalorimetra a obračun COP-a vrši se putem sistemskog PLC-a. Sama toplotna pumpa je sa amonijakom kao prirodnim rashladnim fluidom proizvedena u kompaniji Samifi-ju u Francuskoj. Svojom specifičnom konstrukcijom i naprednim karakteristikama (u pogledu stepena sabijanja, radnog pritiska, promenljivog zapreminskog odnosa, uravnoteženih sila…) predstavlja idealno rešenje za primenu u režimima u kojima rade toplotne pumpe. Izmenjivači toplote na otpadnom vazduhu i izmenjivači u rekuperatoru su nemačkog proizvođača THERMOFIN koji je jedini mogao da ponudi izmenjivače koji u potpunosti ispunjavaju sve zahteve iz projektnog zadatka.

2.3 Uštede

Kao osnova za proračun očekivanih ušteda u potrošnji prirodnog gasa uzeti su sledeći parametri:

1. Proizvedena toplotna i rashladna energija za 3 predviđena režima rada toplotne pumpe sa odgovarajućim vrednostima COP:

Tabela 2. Prikaz režima rada i koeficijenta efikasnosti COP

Spoljašnja temperatura	COP na vratilu komp.	COP toplotne pumpe	COP sistema	COP kombinovani
$+37^0$C	4,47	4,20	3,76	6.46
$+20^0$C	5,32	5,01	4,31	5.45
$+1^0$C	5,46	5,14	4,46	4.82

COP na vratilu kompresora , prema podacima proizvođača kompresora.

COP toplotne pumpe, uzeti su u obzir gubici u elektromotoru i frekventnom regulatoru.

COP sistema, odnos toplotne energije isporučene od strane toplotne pumpe i ukupno uložene

COP kombinovani, predstavlja odnos dobijene toplotne i rashladne energije sa ukupno uloženom električnom energijom sistema.

2. Mesečni utrošak energije u sušarama i klijalištima po toni proizvedenog slada
3. Troškovi održavanja toplotne pumpe na osnovu preporuka proizvođača
4. Procena kretanja cena električne energije i prirodnog gasa
5. Ukupni troškovi investicije ugradnje toplotne pumpe, u koju spadaju: toplotna pumpa, Izmenjivači toplote, cirkulacione pumpe i prohromski cevovod, transformator 1000 kVA, automatsko upravljanje sistemom TP, građevinski radovi, elektro radovi, izolacija cevovoda i punjenje sistema 30% etilen-glikolom (50 m^3)

3. Zaključak

Kroz prikaz ovog rada vidi se da je opravdana primena amonijačnih toplotnih pumpi u industriskim procesima kao što je u ovom slučaju proces u sladari , gde se vrši ušteda u potrošnji prirodnog gasa. Analizom je pokazano da je takva investicija otplativa za cca 3.8 god. Ako se uzme da je uobičajeni vek eksploatacije postrojenja od 16 god. Onda su finansiski efekti značajni.

U ovom slučaju je primenjena toplotna pumpa sa malim sadržajem amonijaka (240 kg) u odnosu na toplotnu snagu (cca 2 MW) što je veoma značajna karakteristika procesa eksploatacije postrojenja sa stanovišta sigurnosti.

Kada je u pitanju zaštita čovekove okoline primenom amonijačne toplotne pumpe se ostvaruje dvostruki efekat:

- primenjuje se prirodni rashladni fluid, čime se umanjuje uticaj na efekat staklene bašte i degradaciju ozonskog omotača.
- Smanjenje uticaja sagorevanja prirodnog gasa što takođe utiče na smanjenje efekta staklene bašte.

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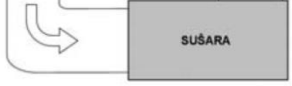

Tok strujanja vazduha u sušari

1. Postojeći cevasti izmenjivač u rekuperatoru
2. Novi izmenjivač

APPLICATION OF INDUSTRIAL AMMONIUM HEAT PUMPS IN MOLD PRODUCTION

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This paper shows comprehensive solution of implementation of heat pump in technological process of making malt. Aim of heat pump implementation is, first of all, saving of natural gas use in production process od drying malt. This solution has a positive influence on lowering greenhouse effect caused by fossil fuel combustion as well. Based on design task we got from investor, scheme of preliminary design is given and, based on it, detailed technological scheme of heat pump installation is made. Characteristic of this type of technological processes is that in certain time period refrigerating effect (heat source for heat pump) and heat of condensation, which is use for fresh air preheating, could be used simultaneously. In this periods COP of systems goes over 6. In this case ammonia heat pump from producer Samifi is chosen. Heat exchangers in recuperator and on waste air are selected to fulfill all demands from design task. In malt cooling and water supply circuit plate heat exchangers are implemented. Based on system calculation using equipment producers's data, COP of system is calculated and it is guaranteed by contractor Tehnomag Teco. Based on this COP natural gas savings are calculated together with return of investment calcualtion

Keywords: *Industrial Ammonia Heat Pumps; Malt Production; Reduction of Natural Gas Consumption, Renewable Heat Sources, Environmental Protection*

1. Introduction

Industrial heat pumps that are categorized as renewable energy sources that contribute to environmental protection by reducing CO_2 emissions into the atmosphere, as well as reducing production costs, with ammonia as a natural coolant, It is a technical solution that has a worldwide expansion [1-2]. If these heat pumps are used in a processes where, in addition to the heating effect, the cooling effect can also be used, then their efficiency is unmatched.

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In this regard, the French corporation SUFFLET, which is Europe's largest and even the world malt producer for the brewing industry, has installed heat pumps in several of its malt plants to reduce the consumption of natural gas in the malt drying process. Tehnomag-Teco from Novi Sad has been chosen as the best technical solution for its Maltinex malt company in Serbia.

During the malt drying process, one part of the air (in this case 400,000 m^3 / h) is discarded, so-called waste air, in order to reduce the moisture content of the air which entering the dryer. Fresh air is injected in the same amount, Figure 1. The first heating of the intake air is in the tubular exchangers, where the fresh air is heated by the exhaust air flow in the figure marked 1. The idea is to carry out an additional increase of the fresh air temperature before entering the dryer by the heat exchangers marked 2 (Figure 1).

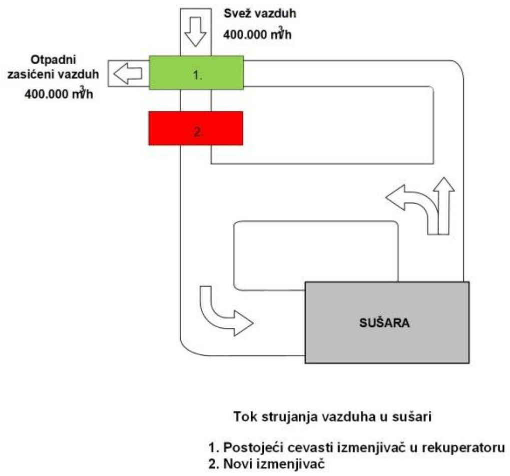

Figure 1 Scheme of air flow in the dryer

2. Methodology and results

2.1. Project assignment

For this purpose, a project task was set by the investor to offer a heat pump with the following design parameters: Heating power about 2MW; Air flow 400,000 m^3/h; Max. exhaust air temperature after glass exchangers 34^0C; Min. exhaust air temperature after glass heat exchangers 18^0C (Cooling water temperature 6-9^0C); condenser outlet water temperature summer period, transition period, winter 55/50 /45^0C; heat exchanger requirement, air heat exchangers; Cu/Al exchanger block; Blade spacing > 5 mm Blade thickness 0.35 mm; Pipe wall thickness > 0.8 mm; regular layout; Heat exchangers for use; Stainless steel / AlMg exchanger block; Blade spacing 10 mm; Blade thickness min. 0.35 mm and pipe wall thickness 0.4mm.

Table 1. Tabular presentation of design parameters

Working conditions	**Ext1°C**	**Ext20°C**	**Ext37°C**
Evaporation temperature	**+3,0°C**	+6,0°C	+3,3°C
Condensation temperature	**+46°C**	+51°C	+56°C
Economizer	yes	yes	yes
Speed of electric motors	2950 rpm	2750 rpm	3150 rpm
Cooling capacity	1514 kW	1519 kW	1409 kW
Absorbed power	338,6 kW	350,4 kW	406,3 kW
Condensation heat	1848 kW	1865 kW	1815 kW
Cooled fluid	MEG 30%	MEG30%	MEG 30%
Inlet temperature	+10°C	+12,9°C	+10°C
Outlet temperature	+6°C	+9°C	+6°C
Volume flow	351 m^3/h	358 m^3/h	327 m^3/h
Capacity	1514 kW	1519 kW	1409 kW

Table 1. Tabular presentation of design parameters (continued)

Working conditions	Ext1°C	Ext20°C	Ext37°C
Heated fluid	MEG 30%	MEG30%	MEG30%
Inlet temperature	+35°C	+40°C	+46,7°C
Outlet temperature	+45°C	+50°C	+55°C
Volume flow	172 m^3/h	173 m^3/h	206 m^3/h
Capacity	1848 kW	1865 kW	1815 kW

Since the drying plant runs year-round, the operating parameters of the heat pump system have been calculated on a project basis over three periods: winter, transitional and summer. Based on the calculated COP of the system, a guarantee for the quality of work and a guarantee of the COP of the system were provided by the main contractor of the company Tehnomag-Teco.

2.2. Technical solution

The main source of heat that is constantly available is the waste air heat that is exchanged in the heat exchangers [3-4]. A significant source of heat available in the summer is heat obtained from barley cooling during germination and exchanged in a plate exchanger. A less significant heat source, that is also used, is cooling water for wetlands (where barley is soaked before germination).

The heat obtained from the condenser side of the heat pump is transferred to the fresh air in the heat exchangers. Secondary heat carrier, on the evaporator and condenser side, is TP 30% water-ethylene glycol solution. In order to obtain thermal energy on the condenser TP, declared for a certain period of time, it is necessary to have sufficient thermal load on the evaporator. This is achieved by maintaining the temperature of the mixture at the outlet of the evaporator, by changing the speed of the circulation pump electric motors in the exhaust air circuit and the circulation pump in the cooling circuit in the ponds.

Control of the operation of the TP and circulation pumps in the primary evaporator circuit and the 100/210 condenser circuit is performed via the TP PLC. The control of the whole system is performed by the PLC system. The calculation of the heat supplied to fresh air is done by means of a calorimeter and the calculation of COP is done also by the PLC system. The heat pump itself, with ammonia as a natural coolant, was manufactured by Samifi in France. With its specific construction and advanced features (in terms of compression ratio, operating pressure, variable volume ratio, balanced forces ...), it is an ideal solution for use in heat pump operating modes. Exhaust air heat exchangers and recuperators are from German manufacturer THERMOFIN, which was the only one that could offer heat exchangers that fully meet all the requirements of the project.

2.3. Savings

The following parameters were taken as the basis for calculating the expected savings in natural gas consumption:

1. Production of heat and cooling energy for 3 predicted modes of operation of heat pump with corres ponding COP values;

Table 2. Operating modes and efficiency ratios COP

Exterior temperature	COP on the compressor shaft	COP of the heat pump	COP of the system	COP combined
+37^{0}C	4,47	4,20	3,76	6.46
+20^{0}C	5,32	5,01	4,31	5.45
+1^{0}C	5,46	5,14	4,46	4.82

COP on the compressor shaft, according to the compressor manufacturer.

COP of the heat pumps, losses in the electric motor and the frequency controller were taken into account.

COP of the system, the ratio of heat energy delivered by the heat pump and the total invested

COP combined represents the ratio of heat and cooling energy obtained to the total electricity input of the system

2. Monthly energy consumption in dryers and germany per tonne of malt produced
3. Maintenance costs of the heat pump based on the manufacturer's recommendations
4. Estimation of price trends of electricity and natural gas
5. Total cost of investment for installation of heat pump, including: heat pump, heat exchangers, circulation pumps and chromium pipeline, 1000 kVA transformer, automatic control of TP system, construction works, electrical works, pipeline insulation and system filling with 30% ethylene glycol (50 m^3).

3. Conclusion

This paper shows justification of ammonia heat pumps implementation in industrial processes, in malt production in this case with savings in natural gas consumption is achieved. Analyze shows payback of 3,8 years. Having in mind usual plant operating life of 16 years, it is easy to conclude that positive financial effects are significant. In this case heat pump with low ammonia content (240 kg) compared to heating capacity of about 2 MW, is implemented and so important from safety standpoint.

Concerning environmental protection is in question, ammonia heat pump implementation has double positive effects:

- Implementation of natural refrigerant lowering greenhouse effect and ozone layer degradation
- Lowering natural gas combustion lower greenhouse effect as well.

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[1] Jing Zhang, Hong-Hu Zhang, Ya-Ling He, Wen-Quan Tao, A comprehensive review on advances and applications of industrial heat pumps based on the practices in China, Applied Energy 178 (2016) 800–825

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