# MOGUĆNOSTI UŠTEDE ELEKTRIČNE ENERGIJE U ELEKTROENERGETSKOM SISTEMU BIH

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***Izvorni naučni rad***

**SAŽETAK**

*Tokom nastale energetske krize, prije svega u EU ali i u našem regionu, vlade u regionu intenzivno pokušavaju da decentralizuju proizvodnju u energetskom sektoru podsticanjem izgradnje novih proizvodnih objekata i podsticanjem građana da proizvode električnu energiju. Najveći broj obnovljivih izvora električne energije (OIE) se priključuje na elektroenergetsku distributivnu mrežu (EDM), tzv. distributivni generatori (DG) a što ponovo zahtjeva dodatna ulaganja i u samu EDM. U svemu tome propušta se sagledavanje mogućnosti uštede električne energije u pogledu smanjivanja gubitaka električne energije na elektroenergetskom sistemu (EES) BiH, prije svega samoj EDM. Bosna i Hercegovina ima veliki potencijal za izgradnju novih proizvodnih objekata, kako velikih elektrana tako i DG, ali isto tako i značajan prostor za uštede električne energije u samom EES, uz neuporedivo manja investiciona ulaganja nego što je to slučaj sa izgradnjom novih proizvodnih objekata. U predmetnom radu prikazaće se mogućnosti ušteda električne energije u BiH i regionu i na konkretnom primjeru dokazati mogućnosti postizanja tehničkih parametara rada EDM a koji su na nivou dobre evropske prakse u predmetnom polju rada.*

***Ključne riječi:*** *elektroenergetski sistem, elektrodistributivna mreža, distributivni gubici*

# POSSIBILITIES OF SAVING ELECTRICITY IN THE ELECTRIC POWER SYSTEM OF BOSNA AND HERZEGOVINA

**SUMMARY**

*During the actual energy crisis, primarily in the EU but also in our region, governments in the region are intensively trying to decentralize production in the energy sector by encouraging the construction of new production facilities and encouraging citizens to produce electricity. The largest number of renewable sources of electricity (RES) are connected to the so-called electricity distribution network. distribution generators (DG), which again requires additional investments in the distribution network itself. In all of this, consideration of the possibility of saving electricity in terms of reducing electricity losses on the electric power system of Bosnia and Herzegovina, primarily the electricity distribution network (EDN), is missed. Bosnia and Herzegovina has great potential for the construction of new production facilities, both large power plants, and DG, but also a significant space for electricity savings in the power system itself, primarily EDN, with incomparably smaller investments than is the case with the construction of new production facilities. In the subject paper, the possibilities of saving electricity in BiH and the region will be presented, and on a concrete example, the possibilities of achieving the technical parameters of EDM work, which are at the level of good European practice in the subject field, will be demonstrated.*

***Keywords****: power system, power distribution network, distribution losses*

# 1 UVOD

Tokom aktuelne energetske krize, cijene struje na berzama dostigle su do sada nezabilježene vrijednosti, a elektroprivrede u BiH i regionu na sve načine pokušavaju da smanje potrošnju građana, kojima se struja obračunava po regulisanim tarifnim cijenama, a sve u cilju izvoza i prodaje viškova na inostranim tržištima. U prilog tome građani se podstiču na izgradnju malih fotonaponskih elektrana na svojim objektima, čija bi osnovna namjena bila proizvoditi električnu enegiju za vlastite potrebe i smanjiti potrebu domaćinstava za električnom energijom na mínimum. Bosna i Hercegovina ima veliki potencijal za izgradnju novih proizvodnih objekata, kako velikih elektrana tako i DG. U Strategiji razvoja energetike BiH do 2035. godine data je lista potencijalnih kapaciteta za proizvodnju električne energije, gdje su prepoznati projekti u hidroelektranama i vjetroelektranama instalisane snage veće od 10 MW. Ostali oblici proizvodnje iz OIE, uključujući male hidroelektrane, solarne fotonaponska elektrane date su kao zbirni planirani kapaciteti. Detaljniji prikaz planiranih investicija, uključujući i proizvodne objekte manje snage od 10 MW navodi se u dokumentima energetskih strategija koji se donose na entitetskim nivoima.

Najveći broj obnovljivih izvora električne energije (OIE) generalno se priključuje na elektroenergetsku distributivnu mrežu (EDM), tzv. distributivni generatori (DG). U ovu kategoriju spadaju male hidroelektrane, solarne elektrane, vetroelektrane i elektrane na biomasu. Ipak, priključenje DG ponovo zahtjeva dodatna ulaganja i u samu EDM. U svemu tome propušta se sagledavanje mogućnosti uštede električne energije u pogledu smanjivanja gubitaka električne energije na elektroenergetskom sistemu (EES) BiH, prije svega samoj EDM, uz značajno manja ulaganja. Cilj predmetnog rada jeste prije svega skrenuti pažnju na mogućnosti oslobađanja značajnih postojećih poizvodnih kapaciteta u BiH smanjivanjem gubitaka električne energije na EES BiH, prije svega na elektrodistributivnoj mreži, dati jasne stručne smjernice za postizanje zacrtnih ciljeva te na osnovu ličnog iskustva u primjeni predmetnih znanja u praktičnim implementacijama dokazati mogućnosti postizanja ciljanih parametara rada sistema.

# 2 ELEKTROENERGETSKI SISTEM BIH

Elektroenergetski sistem BiH je razvijen u prethodnom periodu za potrebe bivše Jugoslavije, tako da ima slične karakteristike sa ostalim bivšim jugoslovenskim zemljama. Proizvodnja energije bazirana je pretežno na konvencionalnim termoelektranama i hidroelektranama uz jake interkonekcije sa susjednim zemljama, sa velikim prenosnim kapacitetima i velikim instalisanim snagama čvorišnih visokonaponskih trafostanica.

Visokonaponska elektroenergetska mreža BiH razvijena je na tri naponska nivoa, 400 kV, 220 kV i 110 kV. Dalekovodi i trafostanice naponskog nivoa 110 kV, 220 kV i 400 kV u vlasništvu su elektroprenosne kompanije Elektroprenos BiH, koja je podjeljena na četiri regiona a čije je sjedište locirano u Banja Luci. Elektroenergetska djelatnost u BiH vrši se putem elektroprivrednih preduzeća i to: Elektroprivreda Republike Srpske (ERS), Elektroprivreda Bosne i Hercegovine (EP BiH), Elektroprivreda Hrvatske zajednice Herceg Bosne (EP HZHB) i Komunalno Brčko u čijem sastavu je i Elektrodistribucija Distrikta Brčko (EDBD). Elektroenergetska djelatnost u svim navedenim preduzećima podjeljena je na djelatnost proizvodnje električne energije i elektrodistributivnu djelatnost. Najviši naponski nivo u BiH i regionu

predstavlja sistem 400 kV dalekovoda i elektroenergetskih postrojenja.

Dalekovodima 400 kV povezan je elektroenergetski sistem BiH sa susjednim sistemima: Srbije (DV 400 kV Ugljevik – Sremska Mitrovica), Hrvatske (DV 400 kV Ugljevik – Ernestinovo i DV 400 kV Mostar – Konjsko) i Crne Gore (DV 400 kV Trebinje – Lastva). Dobra povezanost sa susjednim sistemima omogućava značajnije izvoze, uvoze i tranzite električne energije preko prenosne mreže, te svrstava BiH u vrlo važno tranzitno i elektroenergetsko područje Jugoistočne Evrope. Kada se posmatra region Jugoistočne Evrope u višegodišnjem kontinuitetu uočava se zbirni manjak električne energije od oko 30 000 GWh. Poređenja radi, BiH je u 2021. godini proizvela oko 17 000 GWh. Ovo daje povoljne prilike za izvoz viškova električne energije iz BiH na regionalnoj osnovi.

Značajan porast prihoda od izvoza u 2021. godini ostvaren je zbog vrtoglavog porasta cijena električne energije na tržištu. Poređenja radi, od oko 50-75 €/MWh koliko se kretala cijena električne energije na berzama tokom 2020. cijena iste tokom 2021. dostizala je i do nevjerovatnih 700 €/MWh. Naravno, kako je energetski sistem u stalnoj ravnoteži i stalnom balansiranju EES BiH takođe i uvozi električnu energiju.

U tabeli 1 dat je pregled osnovnih elektroenergetskih pokazatelja BiH za period od 2019. do 2022. u kome se jasno uočava suficit proizvedene električne energije u odnosu na potrebu za potrošnjom.


*Slika 1 – Pregledna karta EES BiH, izvor: https://www.derk.ba/sr/ees-bih/karta-ees*

| | | 2 | 2 | 2 | 2 |
|---|---|---|---|---|---|
| Proizvodnja električne | energije | **17.87** | **16.07** | **15.39** | **17.05** |
| Neto uvoz | (GWh) | 3.11 | 2.82 | 3.26 | 3.31 |
| Neto izvoz | (GWh) | 7.69 | 6.56 | 7.32 | 8.19 |
| Ukupna isporučena električna | (GWh) | 13.29 | 12.33 | 11.32 | 12.16 |
| Ukupna potrošnja električne | (GWh) | **13.29** | **12.33** | **11.32** | **12.16** |
| Gubici prenosa | (GWh) | 39 | 32 | 31 | 36 |
| Gubici prenosa | (%) | 1, | 1, | 1, | 1, |
| Gubici distribucije | (GWh) | 95 | 93 | 91 | 96 |
| Gubici distribucije | (%) | 9, | 9, | 9, | 9, |

*Tabela 1 – Osnovni elektroenergetski pokazatelji BiH u period od 2018. – 2021. godine [1]*

## 3 GUBICI ELEKTRIČNE ENERGIJE U DISTRIBUTIVNOM SISTEMU BIH

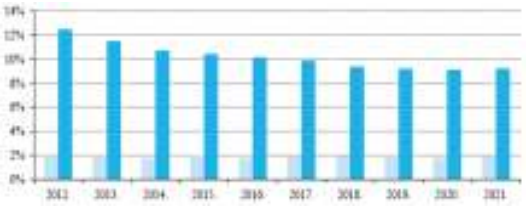
Distributivni gubici su neminovnost svakog elektroprivrednog preduzeća u svijetu pa tako i BiH. U elektroprivredama razvijenijih zemalja EU i svijeta visina distributivnih gubitaka se svodi na tehničke gubitke prilikom prenosa električne energije preko EDM dok je učešće netehničkih gubitaka (neovlaštenog korištenja električne energije i sl.) svedeno na zanemarljivu mjeru. Sa gledišta energetske efikasnosti i ekonomske efektivnosti, gubici u distribuciji električne energije zbog njihove veličine predstavljaju veliki problem elektrodistributivnih preduzeća.

Najkraće rečeno distributivni gubici predstavljaju energiju koja se izgubi, ne fakturiše se i predstavlja izgubljeni prihod preduzeća u finansijskom smislu.

Kako BiH uvodi slobodno tržište električnom energijom, a i pridruživanje EU zahtijeva ispunjavanje određenih propisa i standarda koje propisuje EU, koji se do sada nisu primjenjivali u BiH u pogledu stimulativne politike prema distributivnim kompanijama. Između ostalih tu su i pravila koja primoravaju elektrodistributivna preduzeća da nabavljaju električnu energiju potrebnu za pokrivanje elektrodistributivnih gubitaka prema tržišnim uslovima, što je sada već zakonski usvojena obaveza.

Prema tome BiH u narednom periodu mora značajnije raditi u pogledu poboljšanja energetske efikasnosti distributivne mreže, a da bi se to što konkretnije postiglo potrebno je uvesti stimulativnu politiku prema distributivnim kompanijama. Za sada regulatorna tijela vrše određene proračune i odobravaju dio električnih gubitaka elektroprivrednim preduzećima ka neminovan – opravdani trošak poslovanja. Ipak, cijenu tog dijela gubitaka električne energije snose krajnji korisnici distributivnog sistema a to su građani.

Neododobreni dio gubitaka elektrodistribucije primorane su da nabavljaju, što im predstavlja izgubljeni prihod preduzeća u finansijskom smislu.



*Slika 2 - Procenat prenosnih i distributivnih gubitaka u BiH u periodu 2012. – 2021., Izvor: https://www.derk.ba/DocumentsPDFs/DERK-Izvjestaj-o-radu-2021-s.pdf*

Jedan od glavnih zadataka elektroprivrede je obezbijediti pouzdanu električnu energiju kupcima na razuman način te obezbjediti konkurentne cijene električne energije. Regulatorne agencije i institucije snažno promovišu poboljšanje efikasnosti snabdijevanja električnom energijom. Očigledno je da nizak nivo ulaganja može dovesti do nepouzdanog snabdijevanja (neprihvatljivo mali kontinuitet), dok prekomjerna ulaganja mogu rezultovati nepotrebnim izdacima i povećanjem cijene električne energije za kupce. Prilagođavanje tržišnim uslovima elektrodistributivnih preduzeća ipak mora biti postepeno. Djelatnost distribucije električne energije predstavlja djelatnost od javnog značaja i ne smije se dozvoliti ugrožavanje poslovanja ili funkcionisanje elektrodistributivnih preduzeća zbog naglih skokova cijena električne energije na tržištu. Naime, stav autora predmetnog rada je da distributer treba snositi rizik količine ostvarenih gubitaka, ali nikako i cijene te energije, jer zadatak distributera nije tržište električne energije i spekulativa, već pouzdana i ekonomična distribucija iste do svih korisnika mreže. Rizik promjene cijene ove energije treba obavezno izbaciti iz poslovanja svih elektrodistributivnih preduzeća.

Dobar pokazni primjer iz prakse jeste postupak zaštite elektroprenosne kompanije Elektroprenos BiH od strane državnog regulatornog tijela DERK po istom osnovu. Naime, Elektroprenos BiH nema nikakav rizik po pitanju cijene energije, jer DERK BiH vrši nabavku energije za pokrivanje gubitaka prenosnog sistema.

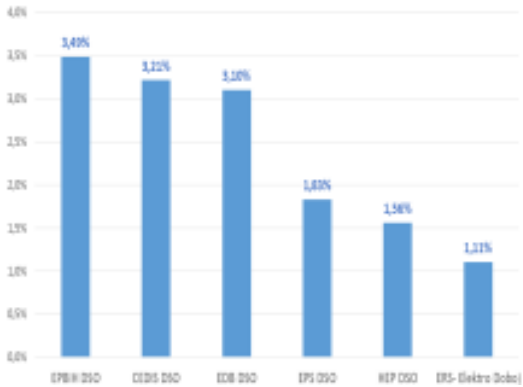
Kao primjer koliki rizik na poslovanje ovo može biti navodimo da je NOS BiH ove godine, zbog dramatičnog rasta cijena ponuda, morao suspendovati „tržišnu“ nabavku i mandatorno odredio, koja je to cijena, te nametnuo obavezu da svi proizvođači u BiH moraju srazmjerno veličini proizvesti energije za pokrivanje tih gubitaka. Odredili su pomenutu cijenu od

109,94 KM/MWh. S druge strane, sva elektrodistributivna preduzeća potrebno je stimulativnim/destimulativnim mjerama tjerati ka efikasnosti u radu sistema, odnosno stimulisati na sve načine rad na smanjenju elektrodistributivnih gubitaka.

# 4 PREGLED MJERA I ISKUSTAVA U POJEDINIM DRŽAVAMA UZ PRIMJER USPJEŠNE PRAKSE U BiH

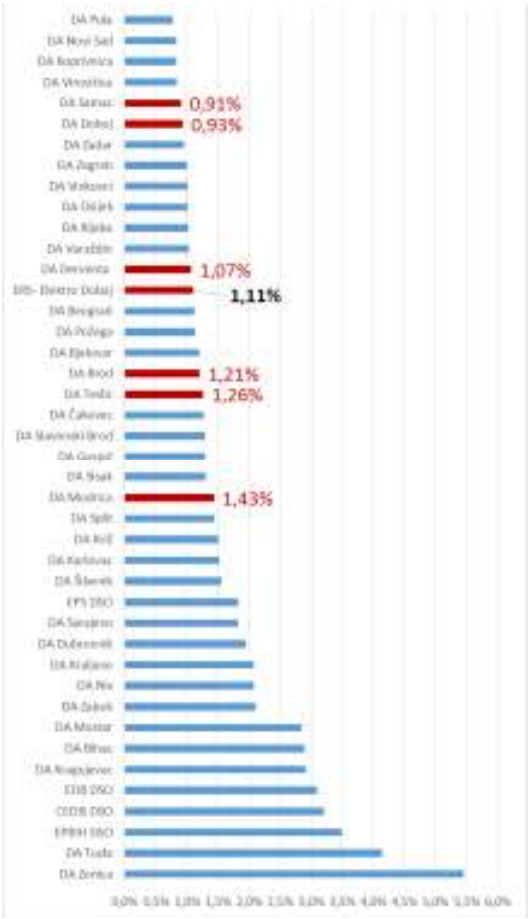
Osnovne tehničke mjere koje se preduzimaju na polju smanjenja distributivnih gubitaka predstavlja povećanje poprečnog presjeka provodnika radi smanjenja gubitaka i poboljšanja naponskih prilika, zamjena energetskih transformatora (ET) radi smanjenja gubitaka u praznom hodu i korekcije vršnog opterećenja, skraćenje NN-izvoda produžavanjem SN-mreže uz zamjenu postojećih ET SN/NN veće snage sa više ET SN/NN manje snage, prelazak sa 10 kV na 20 kV naponski nivo SN mreže, smanjenje tokova reaktivnih snaga na mreži, ovladavanje mjernim mjestom uz uvođenje sistema daljinskog očitanja i daljnskog upravljanja mjernim uređajima, primjena, tzv. pametnih brojila električne energije.

**Mjera 1** - Povećanje poprečnog presjeka provodnika i skraćivanje NN vodova radi smanjenja gubitaka i poboljšanja naponskih prilika




*Slika 3 - Grafički prikaz gubici na NN mreži u odnosu na prenesenu energiju, Izvor: Network Loss Reduction Strategies, USAID/USEA, 2017.*

Osnovna mjera za smanjenje distributivnih gubitaka na NN mreži koja se može i mora primjeniti jeste povećanje poprečnog presjeka provodnika i skraćivanje dužine NN vodova. Na slici 3 dat je grafički prikaz gubitaka na NN mreži u odnosu na prenesenu energiju. U nastavku na slici 4 – prikazana raspodjela gubitaka na NN vodovima u odnosu na distribuiranu električnu energiju po ODS koji posluju na području regiona Jugoistočne Evrope, raščlanjena po teritorijalnim jedinicama. Crvenom bojom markirana su teritorijalna područja ODS-a sa ostvarenim najnižim gubicima na NN mreži u odnosu na ukupnu distribuiranu energiju. Iz datog grafičkog prikaza lako se uočava mogućnost djelovanja u predmetnom cilju na postojećim NN vodovima po ODS-ovima u BiH, posebno u većim centrima: Zenica, Tuzla, Bihać, Mostar.




*Slika 4 - Raspodjela gubitaka na NN vodovima u odnosu na distribuiranu električnu energiju po ODS koji posluju na području regiona Jugoistočne Evrope, raščlanjena po teritorijalnim jedinicama, Izvor: Network Loss Reduction Strategies, USAID/USEA, 2017.*

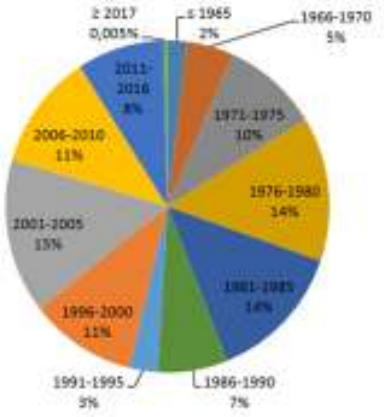
Poređenja radi, u Slovačkoj je povećanje presjeka magistralnih vodova sa standardnih 70 $mm^2$ na 150 $mm^2$ dovelo do smanjenja gubitaka sa 13% na 8%. Predmetna mjera uključuje i povećanje dužine SN mreže uz zamjenu jednog većeg sa nekoliko manjih TR jedinice, što je dodatno smanjilo gubitke u transformatorima za 47%. [3]

**Mjera 2** - Zamjena energetskih transformatora radi smanjenja gubitaka u praznom hodu i korekcije vršnog opterećenja transformatora

Iskustveno rečeno, trećinu svih gubitaka na distributivnoj mreži čine gubici u energetskim transformatorima, pri čemu 66% tih gubitaka čine fiksni gubici, tzv. gubici praznog hoda ET. Najefikasnija mjera za smanjenje distributivnih gubitaka koja se može primjeniti na jednoj EDM predstavlja zamjena ET novim jedinicama sa sniženim gubicima, uz paralelnu optimizaciju snaga ET.

Na slici 5. prikazan je procentualni udio starosne strukture transformatora u BiH. Podaci grafički prikazani na slici 5 ukazuju na činjenicu da je 45% od ukupnog broja transformatora u BiH starije od 40 godina. Pregledom datih podataka uočava se da su mogućnosti na polju zamjene ET i smanjenja gubitaka električne energije velike.

Poređenja radi, u zemljama EU, 20% starih transformatora generiše 35% gubitaka u praznom hodu i 30% promjenljivih gubitaka. Zamjenom ovih transformatora gubici bi se smanjili za 30 000 GWh godišnje, što praktično predstavlja godišnju potrošnju električne energije u Danskoj ili Republici Srbiji. [3]




*Slika 5 - Procentualni prikaz starosne strukture transformatora u BiH, Izvor: Network Loss Reduction Strategies, USAID/USEA, 2017.*

**Mjera 3** - Prelazak sa 10 kV na 20 kV naponski nivo SN mreže

Kao dobar primjer efikasnosti smanjenja gubitaka može se navesti primjer irske

elektrodistributivne mreže. U Irskoj je izvršena rekonstrukcija mreže u ruralnom području, sa prelaskom sa naponskog nivoa 10 kV na naponski nivo 20 kV. Kao rezultat toga pad napona na SN vodovima je prepolovljen, strujna opteretivost vodova je udvostručena a gubici na istim su smanjeni za 75%. [3] Pri ovome je potrebno naglasiti da su razlike u cijenama opreme za 10(12) kV i 20(24) kV naponski nivo neznatne. Predložena mjera jeste efikasna ali nije neophodna. Na primjer, najuspješnije pojedinačnog preduzeća koje ima najmanje gubitke električne energije u BiH nije izvršilo prelaz sa 10 kV na 20 kV naponski nivo rada SN mreže.

**Mjera 4** - Uvođenje sistema daljinskog očitanja i daljinskog upravljanja mjernim uređajima uz primjenu, tzv. pametnih brojila električne energije

Uvođenjem sistema daljinskog očitanja i daljinskog upravljanja mjernim uređajima uz primjenu, tzv. pametnih brojila električne energije postiže se smanjenje ili čak eliminacija netehničkih gubitaka električne energije, smanjenje troškova rada na očitanju brojila i postiže lakše upravljanje mrežom i opterećenjima. Predmetna mjera jeste korisna ali je ipak uslovljena postojanjem tehnički korektne EDM. Prije svega potrebno je imati tehnički ispravnu i pravilno dimenzionisanu distributivnu mrežu pa tek onda stvarati od iste "pametnu mrežu". Poređenja radi, u EU je planirano da se do 2030. godine kod 92% korisnika EDM ugrade pametna brojila. Procjenjena vrijednost investicije iznosi oko 41 milijardi EUR. Kako je prosječna cijena brojila, posmatrajući makro nabavke, 153,3 EUR, to je planirano da se kod 266 miliona krajnjih korisnika ugrade tzv. pametna brojila. [4]

## ZAKLJUČAK

Cilj predmetnog rada bio je prije svega skrenuti pažnju na mogućnosti oslobađanja značajnih postojećih poizvodnih kapaciteta u BiH smanjivanjem gubitaka električne energije na EES, prije svega na elektrodistributivnoj mreži. Kao lice koje se godinama uspješno bavilo predmetnom problematikom primjenjujući ispred navedene konkretne mjere u praksi, autor rada je pokušao kvantifikovati iznesene tvrdnje i jasnim dokazima potkrjepljenim primjerima iz razvijenih zemljama, prije svega EU, kao i primjerima uspješne prakse koje na ovom polju ostvaruju pojedina preduzeća iz BiH. Sagledavanjem osnovnih tehničkih mjera koje bi se realno mogle preduzeti na EDM, uvažavajući sličnosti između dužine mreže po naponskim nivoima, opterećenja mreže, opterećenja ET i brojne druge odlike EDM dolazi se do sledećeg zaključka. Ukoliko bismo smanjili gubitke električne energije za samo 10%, smanjili bismo finansijska opterećenja ED preduzeća za 10,6 mil KM godišnje. Pored toga, uvažavajući prosječnu cijenu koja se trenutno može postići na tržištu od 200 €/MWh, za istu količinu energije koju bi u tom slučaju izvezli postigla bi se zarada od 37,7 mil KM godišnje. Dakle, smanjivanjem gubitaka električne energije za samo 10% za 10 godina ostvarila bi se ukupna ušteda sa kojom bi se mogao napraviti proizvodni objekat veličine HE Buk Bijela na Drini, u sadašnje planiranim gabaritima. Predmetno predstavlja dostižan cilj koji se može ostvariti uz ograničena ulaganja, primjenom ispred navedenih mjera. U ovom slučaju ulaganja u EDM su neuporedivo manja od ulaganja u nove proizvodne objekte.

Ukoliko bi se gubici električne energije na EDM sveli na tehnički dostižnu vrijednost od 6,15%, smanjili bismo finansijska opterećenja ED preduzeća za 35 mil KM godišnje, uprosječeno govoreći. Pored toga, uvažavajući prosječnu cijenu koja se trenutno može postići na tržištu od 200 €/MWh, za istu količinu energije koju bi u tom slučaju izvezli postigla bi se zarada od 64 mil EUR godišnje. Na ovaj način za 7 godina ostvarila bi se ukupna ušteda sa kojom bi se mogao napraviti proizvodni

objekat instalisanoj snage 300 MW, poput TE Stanari. Međutim, već za postizanje ovakvih rezultata neophodno je nekoliko godina intenzivnih investicionih ciklusa i mukotrpnog rada na rekontrukciji postojeće EDM, uz sistemski pristup planiranju i ulaganju prema kriterijumima koji proističu iz ispred navedenih mjera. Primjera radi, ukoliko bismo izvršili zamjenu 80% svih energetskih transformatora SN/NN u BiH uz ugradnju jedinica sa sniženim gubicima vrijednost nabavke istih iznosila bi oko 240 mil EUR. Međutim, rezultat je period povrata investicije od 7-8 godina, uz sve prateće benefite u pogledu poboljšanja poslovanja elektrodistributivnih preduzeća.

Pored toga, stav autora predmetnog rada kada je elektrodistributivno preduzeće u pitanju jeste da distributer treba snositi rizik količine ostvarenih gubitaka, ali nikako i cijene te energije, jer zadatak distributera nije tržište električne energije i spekulativa, već pouzdana i ekonomična distribucija električne energije do svih korisnika mreže. Rizik promjene cijene ove energije treba obavezno izbaciti iz poslovanja svih elektrodistributivnih preduzeća.

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# 1 INTRODUCTION

During the actual energy crisis, the prices of electricity on the stock exchanges have reached previously unrecorded values, and electricity companies in BiH and the region are trying in every way to reduce the consumption of citizens, for whom electricity is calculated according to regulated tariff prices, to export and sell all surpluses abroad markets. In support of this, citizens are encouraged to build small photovoltaic power plants on their buildings, the main purpose of which would be to produce electricity for their own needs and reduce the need of households for electricity to a minimum. For these purposes, incentives are offered and a new category "prosumer". Bosnia and Herzegovina has great potential for the construction of new production facilities, both large power plants and distributed generation power plants (DG). In the Energy Development Strategy of Bosnia and Herzegovina until 2035, there is a list of potential capacities for the production of electricity, where projects in hydroelectric power plants and wind power plants with an installed capacity of more than 10 MW are recognized. Other forms of production from RES, including small hydropower plants and solar photovoltaic power plants, are given as collectively planned capacities. A more detailed description of the planned investments, including production facilities with a power of less than 10 MW, is provided in the energy strategy documents adopted at the entity levels. The largest number of renewable sources of electricity (RES) are generally connected to the electricity distribution network (EDN). This category includes small hydropower plants, solar power plants, wind power plants, and biomass power plants. Including DG again requires additional investments in the EDN itself. In all of this, the opportunity to save electricity in terms of reducing electricity losses on the electric power system (EES) of Bosnia and Herzegovina (BiH), above all the EDN itself, is missed, with significantly smaller investments. The aim of the subject paper is first of all to draw attention to the possibility of freeing significant existing production capacities in BiH by reducing the losses of electricity on the EES of BiH, above all on the electricity distribution network, to give clear professional guidelines for achieving the set goals and based on personal experience in the application of subject knowledge in the practical implementation of the possibility of achieving the target parameters of the system's operation to be confirmed.

# 2 ELECTRICAL ENERGY SYSTEM OF BIH

The electric power system of BiH was developed in the previous period for the needs of former Yugoslavia, so it has similar characteristics to other countries of former Yugoslavia. Energy production is based predominantly on conventional thermal power plants and hydroelectric power plants with strong interconnections with neighboring countries and large installed capacities of hub high-voltage substations. The high-voltage power grid of BiH was developed at three voltage levels, 400 kV, 220 kV and 110 kV. Power transmission lines and substations of voltage levels kV, 220 kV and 400 kV are owned by the power transmission company Elektroprenos BiH, which is divided into four regions and whose headquarters are located in Banja Luka. Electric energy activity in Bosnia and Herzegovina is carried out through electric companies, namely: Power Utility of Republic of

Srpska, Public Company Elektroprivreda Bosne i Hercegovine d.d. - Sarajevo, Elektroprivreda of the Croatian Community of Herzeg-Bosnia (EP HZHB) and Public Utility Company Brčko, which also includes Elektrodistribucija District Brčko (EDBD).

The electrical energy activity in all the mentioned companies is divided into the activity of electricity production and electricity distribution activity.
The highest voltage level in BiH and the region is represented by the system of 400 kV transmission lines and power plants. 400 kV transmission lines connect the power system of BiH with neighboring systems: Serbia (DV 400 kV Ugljevik - Sremska Mitrovica), Croatia (DV 400 kV Ugljevik - Ernestinovo and DV 400 kV Mostar - Konjsko) and Montenegro (DV 400 kV Trebinje - Lastva).


*Figure 1 - Map of the Power System of Bosnia and Herzegovina with Operational Areas of "Elektroprenos BIH" (the Company for Transmission of Electric Power in BIH) and Areas of Public Utilities, Source: https://www.derk.ba/en/ees-bih/ees-map*

A good connection with neighboring systems enables significant exports, imports, and transits of electricity through the transmission network, and places BiH in a very important transit and power area of Southeastern Europe. When looking at the region of South-Eastern Europe, a cumulative shortfall of electricity of around 30,000 GWh can be observed over several years. For the sake of comparison, Bosnia and Herzegovina produced around 17,000 GWh in 2021. This provides favorable opportunities for the export of excess electricity from BiH on a regional basis. A significant increase in export income in 2021 was achieved due to the skyrocketing price of electricity on the market. For the sake of comparison, from around 50-75 €/MWh, which was the price of electricity on the stock exchanges in 2020, the price of the same in 2021 reached an incredible 700 €/MWh. Of course, as the energy system is in constant equilibrium and constant balancing, EES BiH also imports electricity. Table 1 provides an overview of the basic electricity indicators of BiH for the period from 2019 to 2022, in which the surplus of produced electricity in relation to the need for consumption is observed.

| | | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| Production of electricity | (GWh | **17.872.9** | **16.074.0** | **15.390.6** | **17.055.4** |
| Net import | | 3.118.7 | 2.824.9 | 3.266.2 | 3.312.0 |
| Net exports | | 7.697.7 | 6.568.8 | 7.327.4 | 8.197.6 |
| Total delivered electricity | | 13.293.9 | 12.330.1 | 11.329.5 | 12.169.7 |
| Total electricity | | **13.293.9** | **12.330.1** | **11.329.5** | **12.169.7** |
| Transmission losses | | 398.7 | 323.9 | 317.1 | 369.2 |
| Transmission losses | (%) | 1.96 | 1.77 | 1.75 | 1.87 |
| Distribution losses | | 950.0 | 933.2 | 912.6 | 965.0 |
| Distribution losses | (%) | 9.37 | 9.20 | 9.13 | 9.22 |

*Table 1 - Basic electricity indicators of BiH in the period from 2018 to 2021. [1]*

## 3 ELECTRICITY LOSSES IN THE BIH DISTRIBUTION SYSTEM

Distribution losses are an inevitability for every electrical company in the world, including Bosnia and Herzegovina. In the electricity companies of more developed countries of the EU and the world, the amount of distribution losses are reduced to technical losses during the transmission of electricity via EDM, while the participation of non-technical losses (unauthorized use of electricity, etc.) is reduced to a negligible amount. From the point of view of energy efficiency and economic effectiveness, losses in electricity distribution due to their

size represent a big problem for electricity distribution companies. In short, distribution losses represent energy that is lost, is not invoiced and represents the lost income of the company in the financial sense. Since Bosnia and Herzegovina is introducing a free electricity market, EU countries require the fulfillment of certain regulations and standards prescribed by the EU, which have not been applied in Bosnia and Herzegovina in terms of the incentive policy towards distribution companies. Among others, some rules compel distribution companies to purchase the electricity needed to cover electric distribution losses according to market rules, which is now a legally adopted obligation. Therefore, BiH in the coming period must work more significantly in terms of improving the energy efficiency of the distribution network, and in order to achieve this as concretely as possible, it is necessary to introduce a stimulating policy towards the distribution companies of BiH. For now, the regulatory bodies make certain calculations and approve part of the electrical losses to the electrical companies towards the inevitable - justified cost of business. However, the cost of that part of electricity losses is borne by the end users of the distribution system, namely the citizens. Electricity distribution companies are forced to proceed to pay for it themselves the electricity distribution losses through the electricity companies, which represents the lost income of the company in the financial sense.

One of the main tasks of the electricity industry is to provide customers with reliable a electricity supply and competitive electricity prices. Regulatory agencies and institutions strongly promote the improvement of the efficiency of electricity supply. It is over of investment can lead to an unreliable supply (unacceptably low continuity), while excessive investments can result in unnecessary expenses and an increase in the price of electricity for customers. Adaptation to the market conditions of electricity distribution companies must be gradual. The activity of electricity distribution is an activity of public importance and it must not be allowed to endanger the business or functioning of electricity distribution companies due to sudden jumps in electricity prices on the market. Namely, the position of the author of the paper in question is that the distributor should bear the risk of the amount of realized losses, but by no means the price of that energy, because the distributor's task is not the electricity market and speculation, but reliable and economical distribution energy to all users of the network. The risk of changes in the price of energy losses must be removed from the operations of all electricity distribution companies.


*Figure 2 - Percentage of transmission and distribution losses in the period 2012. – 2021., Source: https://www.derk.ba/DocumentsPDFs/BIH-SERC-Annual-Report-2021.pdf*

A good demonstrative example from practice is the procedure for the protection of the electricity transmission company Elektroprenos BiH by the state regulatory body SERC on the same basis. Namely, Elektroprenos BiH does not have any risk regarding the price of energy, because SERC BiH procures energy to cover the losses of the transmission system. As an example of how much of a business risk this can be, we state that NOS BiH this year, due to the dramatic increase in the prices of offers, had to suspend "market" procurement and mandated the price, and imposed the obligation that all producers in BiH must produce in proportion to the size energy to cover those losses. They determined the mentioned price of 109.94 KM/MWh. On the other hand, all electricity

distribution companies need to be pushed towards efficiency in the operation of the ED system by stimulating/disincentive measures, that is, they should be stimulated in every way to reduce electricity distribution losses.

# 4 OVERVIEW OF MEASURES AND EXPERIENCES IN INDIVIDUAL COUNTRIES AND THE EXAMPLE OF SUCCESSFUL PRACTICES IN BiH

The basic technical measures undertaken in the field of reducing distribution losses are an increase in the cross-section of conductors to reduce losses and improve voltage conditions, the replacement of power transformers (ET) to reduce idle losses and correct peak loads, shortening the LV output by extending the MV network with replacement of existing ET MV/LV of a higher power with more ET MV/LV of lower power, the transition from 10 kV to 20 kV voltage level of the MV network, reduction of reactive power flows on the network, control of the measuring point with the introduction of a system of remote reading and remote control of measuring devices with the application, so-called smart electricity meters.

**Measure 1** - Increasing the cross-section of conductors and shortening LV lines to reduce losses and improve voltage conditions

The basic measure to reduce distribution losses on the LV network that can and must be applied is to increase the cross-section of conductors and shorten the length of LV lines. Figure 3 shows a graphic representation of losses on the LV network in relation to the transmitted energy. Below, Figure 4 shows the distribution of losses on LV lines in relation to distributed electricity by DSOs operating in the region of Southeast Europe, broken down by territorial units. The territorial areas of the DSO with the lowest losses on the LV network in relation to the total distributed energy are marked in red. From the given graphic representation, it is easy to see the possibility of acting on the objective in question on existing LV lines by DSOs in BiH, especially in larger centers: Zenica, Tuzla, Bihać, Mostar.

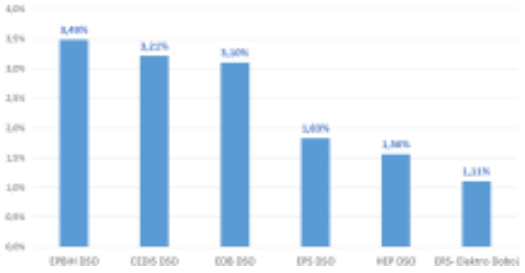

*Figure 3 - Graphic representation of losses on the LV network in relation to the transmitted energy of the DSO in the region, Source: Network Loss Reduction Strategies, USAID/USEA, 2017.*

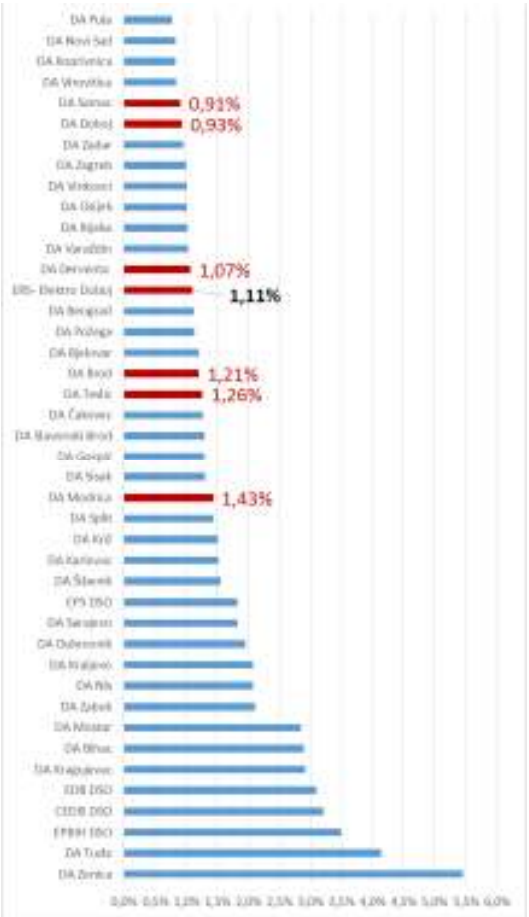

*Figure 4 - Distribution of losses on LV lines in relation to distributed electricity by DSOs operating in the region of Southeast Europe, broken down by territorial units of ODS, Source: Network Loss Reduction Strategies, USAID/USEA, 2017.*

By way of comparison, in Slovakia, increasing the cross-section of main lines from the standard 70 mm2 to 150 mm2 led to a reduction in losses from 13% to 8%. The measure in question includes an increase in the length of the MV network with the replacement of one larger one with several smaller TR units, which further reduced transformer losses by 47%. [3]

**Measure 2** - Replacement of energy transformers to reduce idle losses and correct the peak load of transformers

Empirically speaking, a third of all losses in the distribution network are losses in power transformers, with 66% of these losses being fixed losses, so-called. idle losses ET. The most effective measure to reduce distribution losses that can be applied to an EDN is the replacement of ET with new units with reduced losses, with parallel optimization of ET power.

Figure 5 shows the percentage share of the age structure of transformers in Bosnia and Herzegovina. The data shown graphically in Figure 5 indicate the fact that 45% of the total number of transformers in Bosnia and Herzegovina are over 40 years old. By reviewing the given data, it can be seen that the possibilities in the field of replacing ET and reducing electricity losses are great.

By comparison, in EU countries, 20% of old transformers generate 35% no-load losses and 30% variable losses. By replacing these transformers, losses would be reduced by 30 000 GWh per year, which practically represents the annual consumption of electricity in Denmark or the Republic of Serbia. [3]

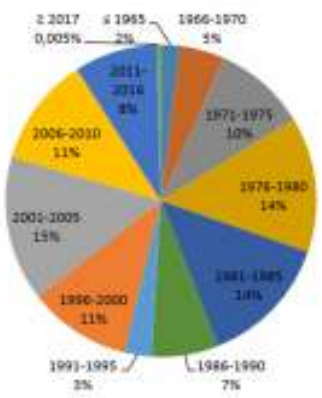


*Figure 5 - Percentage representation of the age structure of transformers in Bosnia and Herzegovina, Source: Network Loss Reduction Strategies, USAID/USEA, 2017.*

**Measure 3** - Transition from 10 kV to 20 kV voltage level of the MV network

The Irish electricity distribution network can be cited as a good example of the effectiveness of reducing losses. In Ireland, the network was reconstructed in a rural area, with the transition from a voltage level of 10 kV to a voltage level of 20 kV. As a result, the voltage drop on the MV lines was halved, the current carrying capacity of the lines was doubled, and the losses on them were reduced by 75%. [3] Here it should be emphasized that the differences in the equipment price for 10(12) kV and 20(24) kV voltage levels are insignificant. The proposed measure is effective but not necessary. For example, the most successful individual company with the least electricity losses in BiH did not transition from 10 kV to 20 kV voltage level of MV network operation.

**Measure 4** - Introduction of a system of remote reading and remote control of measuring devices with the application of the so-called smart electricity meters

By introducing a system of remote reading and remote control of measuring devices with the application of the so-called smart electricity meters reduce or even eliminate

non-technical losses of electricity, reduce labor costs for reading the number, and achieve easier management of the network and loads. The measure in question is useful, but it is conditioned by the existence of a technically correct EDM. First of all, it is necessary to have a technically correct and correctly dimensioned distribution network, and only then to create a "smart network" from it. By way of comparison, in the EU it is planned that 92% of EDN users will have smart meters installed by 2030. The estimated value of the investments is around 41 billion euros. As the average price of the meter, looking at macro purchases, is EUR 153.3, it is planned to install 266 million the so-called smart meters. [4]

## CONCLUSION

The aim of the work in question was, first of all, to draw attention to the possibility of freeing significant existing generating capacities in BiH by reducing the losses of electricity on the EES, above all on the electricity distribution network. As a person who for years successfully dealt with the issue in question by applying the aforementioned concrete measures in practice, the author of the paper tried to quantify the claims made and clear evidence supported by examples from developed countries. primarily the EU, as well as examples of successful practice in this field achieved by individual companies from Bosnia and Herzegovina. By looking at the basic technical measures that could realistically be taken on EDM, taking into account the similarities between the length of the network by voltage levels, network load, ET load and numerous other features of EDM, the following conclusion is reached.

If we were to reduce electricity losses by only 10%, we would reduce the financial burden of ED companies by 10.6 million KM per year. In addition, taking into account the average price that can currently be achieved on the market of 200 €/MWh, for the same amount of energy that would be exported in that case, earnings of 37.7 million KM per year would be achieved. Therefore, by reducing electricity losses by only 10% in 10 years, total savings would be achieved with which a production facility the size of HPP Buk Bijela on the Drina could be built, in the currently planned dimensions. The subject represents an attainable goal that can be achieved with limited investments, by applying the aforementioned measures. In this case, investments in EDN are incomparably smaller than investments in new production facilities.

If the electricity losses at EDN were reduced to a technically achievable value of 6.15%, we would reduce the financial burden of ED companies by 35 million KM per year, on average. In addition, taking into account the average price that can currently be achieved on the market of 200 €/MWh, for the same amount of energy that would be exported in that case, earnings of 64 million EUR per year would be achieved. In this way, in 7 years, total savings would be achieved with which a production facility with an installed capacity of 300 MW, such as TE Stanari, could be built. However, in order to achieve such results, several years of intensive investment cycles and painstaking work on the reconstruction of the existing EDN are necessary, along with a systematic approach to planning and investment according to the criteria resulting from the measures mentioned above. For example, if we were to replace 80% of all MV/LV power transformers in BiH with the installation of units with reduced losses, the value of their procurement would amount to around EUR 240 million. However, a  results in a return on investment period of 7-8 years, with all the accompanying benefits in terms of improvements in the operation of electricity distribution companies.

In addition, the position of the author of the subject paper when it comes to the electricity distribution company is that the distributor should bear the risk of the amount of realized losses, but by no means the price of that energy, because the distributor's task is not the electricity market and speculation, but the reliable and economical distribution of electricity to all users networks. The risk of changes in the price of this energy must be removed from the operations of all electricity distribution companies.

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