dr Miodrag Mesarović

Povodom dodele priznanja TOP ENERGY za izuzetan doprinos nauci i razvoju energetike donosimo rad „Za usmeravanje energetske tranzicije predložen integrisani nacionalni energetski i klimatski plan Republike Srbije do 2030. sa vizijom do 2050. godine" dr Miodraga Mesarovića, Akademija inženjerskih nauka Srbije

On the occasion of awarding the TOP ENERGY award for exceptional contribution to science and energy development we present the work „Integrated national energy and climate plan of the republic of serbia up to 2030 with the projections up to 2050 is proposed for directing energy transition", by DSc Miodrag Mesarović, Academy of Engineering Sciences of Serbia

Za razliku od svih dosadašnjih energetskih tranzicija koje su se odvijale spontanim i dugotrajnim prelaskom sa jednog na drugi glavni izvor primarne energije, tekuća energetska tranzicija se sprovodi pod sveopštim pritiskom da trenutno dominantna fosilna goriva, prvenstveno ugalj, u što kraćem roku budu napuštena i zamenjena ekološki i klimatski prihvatljivijim obnovljivim izvorima primarne energije (OIE). Ta urgentnost potiče od kašnjenja sveta da ublaži posledice rastućih antropogenih emisija gasova sa efektom staklene bašte (GSB) njihovim postepenim smanjivanjem. Kako Kyoto Protokol iz 1997. godine, kao prvi poduhvat globalnog smanjenja emisija za 5,2% do 2012. godine u odnosu na emisije iz 1990. godine, nije dao očekivane rezultate koje su trebalo da ostvari 38 najrazvijenijih zemalja, novi poduhvat, Pariski sporazum iz 2015. godine, obavezao je sve zemlje da smanjuju emisije GSB tako da prosečna globalna temperatura 2100. godine ne poraste više od 1,5 – 2,0 ºC iznad prosečne vrednosti iz perioda pre početka industrijske revolucije, odnosno pre početka masovne upotrebe uglja, a potom nafte i prirodnog gasa za ubrzani rast industrijalizacije.

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Takav globalni poduhvat je izuzetno složen i skup, pa je donekle razumljivo kašnjenje sveta da masovno krene sa neophodnom tranzicijom sa fosilnih na druge vrste primarne energije. Osim teškoća u obezbeđivanju ogromnih finansijskih sredstava, oklevanju doprinose mnogobrojne kontroverze i naučne neizvesnosti u vezi sa izuzetno složenom prirodom i stvarnim uzrocima klimatskih promena, pa čak i negiranje antropogenih uticaja na njihov nastanak prvenstveno od strane globalnih energetskih korporacija, ali i od malog dela (3%) naučne javnosti, uprkos nedavnog alarma iz vrha Ujedinjenih nacija (UN) da globalno „otopljavanje" već prelazi u globalno „ključanje". Logično je očekivati da će nastavljene antropogene emisije GSB sve više otežavati i činiti sve skupljim smanjivanje emisija GSB istovremeno istovremeno sa skupom adaptacijom čovečanstva na opstanak u izmenjenim klimatskim uslovima.

Međutim, optimizam nakon sporazuma na samitu UN o klimi (COP 15) u Parizu 2015. godine postepeno nestaje sa oklevanjem nacija da se obavežu na odricanje od upotrebe fosilnih goriva, pa su i konferencije UN o klimi (COP26) u Glazgovu 2021. godine i naredna (COP 27) 2022. godine u Šarm el Šeiku završene bez dogovora o postepenom ukidanju ili bar smanjenju upotrebe fosilnih goriva. Da razlog za brže delovanje bude jasniji, većina stručnjaka veruje da će, prema trenutno važećim obavezama iz Pariskog sporazuma, globalna temperatura do 2100. godine porasti za oko 2,5ºC, pa bi za svoje ispunjenje ciljeva Pariskog sporazuma, zemlje morale učiniti mnogo više od trenutnih obaveza za smanjenje emisije GSB i utrošiti tri puta više na čistu energiju nego što trenutno troše kako bi dostigle neto-nultu emisiju GSB do 2050. godine i postigle cilj iz Pariskog sporazuma. Razlog za sumnju da će do očekivanog globalnog dogovora doći na predstojećoj konferenciji UN (COP28) u Dubaiu krajem ove (2023.) godine je nedavni neuspeh dogovora između zemalja Grupe G20 da smanje korišćenje fosilnih goriva i utrostruče ulaganje u razvoj izvora obnovljive energije do 2030. godine.

Budući da su najrazvijenije zemlje svoj početni razvoj zasnovale na upotrebi uglja, a potom nafte pa zemnog gasa, i time dovele do porasta atmosferske koncentracije GSB i do poremećaja prirodne ravnoteže u okviru ciklusa ugljenika, od njih je očekivano da finansijski pomognu zemljama u razvoju da što manje koriste fosilna goriva za svoj razvoj i ispunjavaju svoje obaveze smanjenja emisija. Ta pomoć, pa time i veća globalna akcija smanjenja emisija GSB, kasni u odnosu na ranije dogovaranu dinamiku, a rizik od globalne promene klime raste, te bi očekivane promene u budućnosti mogle da ugroze svu postojeću infrastrukturu, proizvodnju hrane, dostupnost vode i javno zdravlje.

Globalno opredeljenje je da se, u cilju smanjenja odnosno prekida ili bar svođenja antropogenih emisija GSB na neto-nulte emisije, energetska tranzicija sprovodi prelaskom sa fosilnih goriva na izvore primarne energije koji tokom rada uopšte ne emituju GSB (hidro, solarna, eolska, geotermalna, nuklearna energija). Još ne postoji opšti konsenzus o nemogućnosti da sve potrebe sveta za energijom u budućnosti zadovoljavaju OIE ("100% RES") računajući pri tome prvenstveno na energetske potencijale biomase, vodenih tokova, sunčevog zračenja i strujanja vazduha kao neiscrpne i čiste („zelene") izvore energije. Uz razumljivo shvatanje da svaki izvor energije, pa i OIE, na neki način utiče na životnu sredinu kako u toku rada, tako i u toku izgradnje i posle razgradnje (obuhvatom celog „životnog ciklusa"), manje je razumevanja da rešenje sa korišćenjem OIE nije beskonačno, jer su prirodni resursi neophodni za njihovu gradnju iscrpljivi - konačni. To se posebno odnosi na kritične minerale koji igraju ključnu ulogu u glavnim tehnologijama čiste energije, kao što su

As opposed to all previous energy transitions, which have been carried out by means of spontaneous and long-term transition from one main source of primary energy to another, current energy transition is carried out under general pressure that currently dominant fossil fuels, primarily coal, have to be given up in the shortest possible time and replaced by environmentally and climate friendly renewable energy sources (RES) of primary energy. This urgency is the result of the delay in the world to mitigate consequences of the effects of increasing anthropogenic emissions of greenhouse gases (GHGs) by means of their phasing out. Since the Kyoto Protocol from 1997, as the first attempt to reduce global emissions by 5.2% until 2012 in relation to emissions in 1990, has not given expected results that were supposed to be achieved by 38 most developed countries, a new attempt, the Paris Agreement from 2015, has obliged all countries to reduce GHG emissions so that the average global temperature in the year 2100 does not rise more than 1.5-2.0ºC above the average value from the period before the beginning of the industrial revolution, that is, before the beginning of the massive use of coal and afterwards of oil and natural gas for the accelerated growth of industrialization.

Such a global mission is extremely complex and expensive and the delay of the world to start necessary extensive transition from fossil fuels to other types of primary energy is somewhat understandable. In addition to difficulties in securing huge financial resources, numerous controversies and scientific uncertainties regarding the extremely complex nature and real causes of the climate change, and even the denial of anthropogenic influences of their origin primarily by global energy corporations, but also by a small part (3 %) of the scientific community, despite the recent alarm from the top of the United Nations (UN) that global "warming" is already turning into global "boiling", have contributed to this hesitation. It is logical to expect that the continuation of anthropogenic GHG emissions will make increasingly more difficult and more expensive the reduction of GHG emissions that will, at the same time, be accompanied by the expensive adaptation of the humanity to the survival in changed climate conditions.

However, the optimism, after the agreement at the UN Climate Summit (COP 15) in Paris in 2015, has been gradually disappearing with the hesitation of nations to commit themselves to give up the use of fossil fuels, so the UN Climate Conferences (COP26) in Glasgow in 2021 and the next one (COP 27) in 2022 in Sharm el-Sheikh have ended without the agreement on phasing out or at least reducing the use of fossil fuels. To make the reason for faster action clearer, most experts believe that, according to currently valid obligations from the Paris Agreement, the global temperature will rise by about 2.5ºC by the year 2100. Therefore, for the fulfillment of their targets from the Paris Agreement, countries will have to do a lot more than their current commitments for the reduction of GHG emissions and spend three times more money on clean energy than they are currently spending in order to reach the net-zero GHG emissions by 2050 and meet the target of the Paris Agreement. The reason for doubts that expected global agreement will be reached at the upcoming UN Conference (COP28) in Dubai at the end of this year (2023) is caused by the recent failure of agreement among G20 countries to reduce the use of fossil fuels and to triple investments in the development of renewable energy sources by 2030.

Taking into account the fact that the most developed countries have based their initial development on the use of coal, and then on the use of oil and natural gas, and thus have caused the increase of the atmospheric concentration of GHGs and the disruption of the natural balance within the carbon cycle, they are expected to financially assist developing countries to use less fossil fuels for their development and to meet their obligations related to the reduction of emissions. This assistance, and thus a larger global action on the reduction of GHG emissions, has been delayed compared to the previously agreed dynamics, while the risk of global climate change is growing, and expected changes in the future can threaten all existing infrastructure, food production, water availability and public health.

In order to decrease and stop or at least lower anthropogenic GHG emissions to net-zero level, the global determination is to carry out energy transition by transferring from fossil fuels to primary energy sources that do not at all emit GHGs during operations (hydro, solar, aeolian, geothermal and nuclear energy). There is still no general consensus on the possibility to meet all energy requirements in the future by means of the RES ("100% RES") taking into account primarily the energy potential of biomass, water flows, solar radiation, and air flow as inexhaustible and clean ("green") sources of energy. There is a reasonable understanding that every source of energy, even the RES, in some way affects the environment not only during operations but also during the construction and afterwards due to the decomposition (by including the whole "life cycle"), but there is less understanding that the solution with the use of RES is not indefinite because natural resources required for their construction are exhaustible - finite. This especially refers to critical minerals that play a key role in most important clean energy technologies, such as solar panels, batteries for electric energy storage, etc. Particular controversies related to the energy transition refer to the use of nuclear energy, which belongs to the category of sour-

solarni paneli, baterije za akumulaciju električne energije i dr. Posebne kontroverze energetske tranzicije se odnose na korišćenje nuklearne energije koja spada u kategoriju izvora koji tokom rada ne emituju GSB niti druge zagađivače kao izvori na fosilna goriva: dok neke evropske zemlje gro svoje električne energije proizvode u nuklearnim elektranama i grade nove, druge ih isključuju iz pogona i zatvaraju, a Srbija i posebnim zakonom zabranjuje gradnju nuklearnih elektrana.

Uticaji klimatskih promena su već uočljivi i u Srbiji (noviji podaci pokazuju da su između 1961. i 2017. godine, temperature rasle za 0,36ºC po deceniji, a u istom periodu su prosečne količine padavina smanjene za oko 10%), pa je logično što Srbija aktivno doprinosi globalnim naporima u borbi protiv klimatskih promena kao članica UNFCCC i potpisnica Kjoto protokola i Sporazuma iz Pariza. Obaveze Srbije nalažu zaokret ka niskougljeničnoj i klimatski prilagodljivoj ekonomiji, pa je inicijalno najavljeno smanjenje emisije GSB za 9,8% do 2030. godine u odnosu na emisije iz 1990. godine prihvatila da uveća preko tri puta.

Kao zemlja kandidat za članstvo u Evropskoj uniji (EU), Srbija ulaže napore da se uskladi sa politikom i akcijama EU. Okvir za klimu i energetiku EU do 2030. godine postavlja tri ključna cilja do 2030. godine: najmanje 40% („fit for 55“) smanjenja emisija GSB u odnosu na nivo iz 1990. godine, najmanje 32% učešća energije OIE i unapređenje energetske efikasnosti od najmanje 32,5%. Energetska zajednica je donela Preporuku 2018/01/MC-EnC za izradu i donošenje Integrisanih nacionalnih energetskih i klimatskih planova (INEKP) za sve članice uključujući i Srbiju, a i Uredba EU 2018/1999 nalaže usklađivanje nacionalnih planova za smanjenje emisija GSB zemalja članica Energetske zajednice sa ciljevima važećim u EU.

Slično kao u većini zemalja, energetski sektor u Srbiji je najveći emiter GSB, te njegova postojeća struktura zahteva značajne promene i ulaganja, kako bi bio usklađen sa evropskom politikom. U tom smislu predlog INEKP Republike Srbije do 2030. sa vizijom do 2050 godine postavlja ambiciozne ciljeve za smanjenje emisija GSB, za povećanje udela OIE, kao i mere za efikasniju potrošnju primarne i finalne energije. Važeća Strategija razvoja energetike Srbije do 2025. sa vizijom do 2030. godine doneta 2015. godine može se smatrati konzervativnom u odnosu na obaveze koje je Srbija preuzimala u međuvremenu. Da u odsustvu nove energetske strategije to kompenzuje, Ministarstvo rudarstva i energetike je donelo Polazne osnove Plana razvoja energetske infrastrukture i mera energetske efikasnosti za period do 2028. sa projekcijama do 2030. godine. U oblasti proizvodnje električne energije, Polazne osnove predviđaju obezbeđivanje energetske nezavisnosti elektroenergetskog sektora, realizaciju projekata gasifikacije ključnih regiona i izgradnju gasnih interkonektora radi diversifikacije pravaca snabdevanja, kao i značajne uštede u potrošnji energije (oko 3-4 TWh godišnje), pri čemu bi najveće uštede trebale da budu ostvarene u toplotnoj energiji primenom mera energetske efikasnosti u domaćinstvima, industriji i ostalim sektorima potrošnje.

Dok se na novu Strategiju razvoja energetike još čeka, Vlada je nedavno (početkom juna 2023. godine) usvojila Strategiju niskougljeničnog razvoja Republike Srbije za period od 2023. do 2030. godine sa projekcijom do 2050. godine. U cilju procene različitih opcija ublažavanja klimatskih promena razvijeno je 6 scenarija smanjenja emisija GSB, od kojih 2 zadržavaju postojeće mere za smanjenje emisija, a 4 predviđaju dodatne mere za smanjenje emisija GSB uključujući preuzimanje i implementaciju zakonodavstva EU u nacionalno zakonodavstvo. Prema najjevtinijem (M2) od 4 scenarija sa dodatnim merama, za predviđeno smanjenje emisija GSB za 33,3% do 2030. i 67,2% do 2050. godine u poređenju sa emisijom u 1990. godini, ukupni procenjeni sistemski troškovi do 2050. godine su najmanje 60 milijardi €. Većinu troškova u scenariju M2 čine troškovi energetskog sektora (46,2 milijarde €), dok su troškovi za stambeni, institucionalni i poslovni sektor 12,7 milijardi €, a za industriju i građevinarstvo sa 8,3 milijardi €. Ovaj (M2) klimatski scenario se može smatrati neizbežnim kada se Srbija pridruži EU, a istovremeno sa najmanje troškova do 2030. godine. Međutim, scenario M3 (sa troškovima 72 milijarde € do 2050. godine) postiže veće smanjenje emisije (45,2%) do 2030. godine, ali zahteva ulaganje za oko 5 milijardi € veće nego ulaganje po scenariju M2, a ostvaruje približno isto (69,0%) smanjenje emisija GSB do 2050. godine u poređenju sa emisijama iz 1990. godine kao i izabrani scenario M2.

Predloženi INEKP Srbije integriše u celinu pet međusobno povezanih oblasti po kategorizaciji Energetske unije: dekarbonizaciju (smanjivanje antropogenih emisija GSB i povećanje udela OIE), povećanje energetske efikasnosti, obezbeđenje sigurnosti snabdevanja potrošača energijom, razvoj unutrašnjeg tržišta energije i podsticanje razvojnih istraživanja, inovacija i konkurentnosti. Dekarbonizacija je u fokusu energetske tranzicije u Srbiji sa posebnim naglaskom na povećanu upotrebu OIE na račun smanjenja upotrebe fosilnih goriva radi smanjenja emisija GSB (u suprotnom, smanjenje emisija u 2030. godini bi sa 29,88% u 2020. godini spalo na 19,37% u odnosu na emisije iz 1990. godine).

Predlog INEKP predviđa smanjenje emisije GSB sa 80,09 MtCO2eq iz 1990. godine na 47,77 MtCO2eq u 2030. godini, tj. za 40,36%. Kako smanjenje emisija GSB do 2030. godine na koje se Srbija obavezala Ujedinjenim nacijama iznosi 33,30%, za razliku od 7,06% INEKP računa na doprinos neto negativnih emisija (ponora) u sektoru korišćenja i promene namene zemljišta i šumarstva (LULUCF), prvenstveno na pozitivni odnos između prirasta i gubitka šumske biomase. Kako su šume posebno ranjive na biotske (štetočine i bolesti) i abiotske (požari) faktore, koji će još biti pogoršani klimatskim promenama, INEKP predviđa sprečavanje svih štetnih uticaji

ces that do not emit GHGs or other pollutants during operations as do fossil fuels. While some European countries produce most of their electricity in nuclear power plants and build new ones, other countries phase out their use and close them down, and Serbia even prohibits the construction of nuclear power plants by a special law.

The effects of climate changes are already noticeable in Serbia (more recent data show that between 1961 and 2017, temperatures are rising by 0.36ºC per decade, and in the same period, the average amount of precipitation decreases by about 10%), so it is logical for Serbia to actively contribute to global efforts in the fight against climate changes as the member of the UNFCCC and the signatory of the Kyoto Protocol and the Paris Agreement. Obligations of Serbia require the turn to low-carbon and climate adapted economy. Although initially had announced its intention to reduce GHG emissions by 9.8% until 2030 in comparison to emissions in 1990, Serbia has accepted to increase that percentage by more than three times.

As a candidate country for the membership in the European Union (EU), Serbia is making efforts to comply with EU policies and actions. The EU 2030 Climate and Energy Framework sets out three key targets until 2030: at least 40% (“fit for 55”) reduction of GHG emissions compared to the level in 1990, at least 32% share of RES and the improvement of energy efficiency of at least 32.5%. The Energy Community has adopted the Recommendation 2018/01/MC-EnC for the preparation and enactment of Integrated National Energy and Climate Plans (INECPs) for all members, including Serbia, and the EU Regulation 2018/1999 demands the harmonization of national plans for the reduction of GHG emissions for all member countries of the Energy Community with targets that are valid in the EU.

The same as in many other countries, the energy sector in Serbia is the largest emitter of GHGs, and its existing structure requires significant changes and investments in order to comply with the European policy. In that respect, the proposal of the INECP of the Republic of Serbia until 2030 with projections until 2050 sets out ambitious targets for the reduction of GHG emissions, for increasing the share of RES, as well as measures for more efficient consumption of primary and final energy. The current Energy Sector Development Strategy of Serbia up to 2025 with Projections up to 2030 adopted in 2015 can be considered conservative in relation to obligations that Serbia has accepted in the meantime. For the purpose of making up for this in the absence of a new energy strategy, the Ministry of Mining and Energy has enacted Starting Bases for the Plan of the Development of Energy Infrastructure and Energy Efficiency Measures for the Period up to 2028 with Projections up to 2030. In the field of electricity production, Starting Bases anticipate ensuring energy independence of the electricity sector, the implementation of gasification projects in key regions and the construction of gas interconnectors in order to diversify routes of energy supply, as well as significant savings in the consumption of energy (about 3-4 TWh per year). At that, the biggest savings should be achieved in thermal energy by applying energy efficiency measures in households, industry, and other sectors of consumption.

While still waiting for the new Energy Sector Development Strategy, the Government has recently adopted (at the beginning of June 2023) the Low Carbon Development Strategy of the Republic of Serbia for the Period from 2023 to 2030 with Projections up to 2050. For evaluating different options for mitigating climate changes, 6 scenarios for reducing GHG emissions are developed, 2 of which keep existing measures for the reduction of emissions, and 4 anticipate additional measures for the reduction of GHG emissions, including the adoption and implementation of the EU legislation in the national legislation. According to the cheapest (M2) of 4 scenarios with additional measures, for the anticipated reduction of GHG emissions by 33.3% until 2030 and by 67.2% until 2050 in comparison to emissions in 1990, the total estimation of the costs until 2050 are at least EUR 60 billion. Most of the costs in the M2 scenario are the costs of the energy sector (EUR 46.2 billion), while the costs for the residential, institutional, and business sectors are EUR 12.7 billion, and EUR 8.3 billion for industry and construction. This climate scenario (M2) can be considered inevitable when Serbia joins the EU, and at the same time, with the lowest costs until 2030. However, the M3 scenario (with costs of EUR 72 billion by 2050) achieves the higher reduction of emissions (45.2%) by 2030, but requires the investment of about EUR 5 billion higher than those according to the M2 scenario and achieves approximately the same (69.0%) reduction of GHG emissions by 2050 in comparison to emissions in 1990 as the selected scenario M2 does.

The proposed INECP of Serbia integrates into one unit five mutually connected areas according to the categorization of the Energy Union: the decarbonization (the reduction of anthropogenic GHG emissions and the increase of the use of RES), the increase of energy efficiency, ensuring secure energy supply to consumers, the development of the internal energy market and encouraging development of researches, innovations, and competitiveness. The decarbonization is in the focus of the energy transition in Serbia with a special emphasis on the increased use of RES at the expense of the reduction of the use of fossil fuels in order to decrease GHG emissions (otherwise, the reduction of emissions in 2030 will fall from 29.88% in 2020 to 19.37 % in comparison to emissions in 1990).

The INECP proposal anticipates the reduction of GHG emissions from 80.09 MtCO2eq in 1990 to 47.77 MtCO2eq in 2030, that is, by 40.36%. Since the reduction of GHG emissions until 2030 to which Serbia is committed to the United Nations amounts to 33.30%, for the difference of 7.06%, the INECP takes into account the contribution of net negative emissions (sinks) in the sector of land use, land-use change, and forestry (LULUCF), primarily on the positive relations between the yield and the loss of the forest biomass. As forests are particularly vulnerable to biotic (pests and diseases) and abiotic (fires) factors, which will be worsened by climate changes, the INECP anticipates the prevention of all harmful effects accompanied by sustainable forest management taking into account future climate conditions.

In order to achieve the target for the reduction of GHG emissions by 40.36% in 2030 in comparison to 1990, anticipated decarbonization measures until 2030 in connection with thermal power plants imply the reduction of the production of electricity

uz održivo gazdovanje šumama uzimaju u obzir buduće klimatske uslove.

Za postizanje cilja smanjenja emisije GHG za 40,36% u 2030. godini u odnosu na 1990. godinu, predviđene mere dekarbonizacije do 2030. godine u vezi sa termoelektranama svode se na smanjenje proizvodnje električne energije na ugalj do 2030. godine za 25 % u odnosu na proizvodnju električne energije iz termoelektrana u 2020. godini i na neophodnu modernizaciju rudarskog sektora radi obezbeđenja uslova za stabilan pogon postojećih elektrana na lignit. Za postizanje navedenih ciljeva smanjenja emisija GSB i ispunjenje obaveze koje Srbija ima po osnovu članstva u Energetskoj zajednici u skladu sa Odlukom EZ br. 2022/02/MC-EnC, INEKP predviđa da udeo OIE u bruto finalnoj potrošnji energije poraste sa 26,30% u 2020. na 33,6% z 2030. godini, pri čemu je planirani udeo OIE u proizvodnji električne energije 45,20% (saglasno posebnim obavezama koje je Srbija preuzela prema MMF i drugima kreditorima), 41,4% u energiji utrošenoj na grejanje i hlađenje i 7% energije iz OIE u saobraćaju.

Energetska efikasnost je za Srbiju važna oblast zbog toga što je danas potrošnja energije po jedinici proizvoda za 50% viša od proseka u zemljama članicama EU. Fokusiranje na energetsku efikasnost, posebno za domaćinstva i privredu, izgleda kao imperativ (istraživanja su pokazala da 85% stambenih zgrada u Srbiji ne ispunjava minimalne zahteve energetske efikasnosti). Predloženi INEKP predviđa da 2030. godine ukupna potrošnja primarne energije bude 14,69 Mtoe, a potrošnja finalne energije 9,67 Mtoe. To je značajna ušteda jer bi bez primene predloženih mera potrošnja primarne energije u 2030. godini sa sadašnjih (2020. godine) 15,08 Mtoe dostigla 17,53 Mtoe, a potrošnja finalne energije sa 8,89 Mtoe bi dostigla 10,91 Mtoe.

Planirana proizvodnja električne energije u 2030. godini bi sa sadašnjih (2020. godine) 37,62 TWh porasla na 40,19 TWh umesto na 45,89 TWh bez planiranih mera. Da to ostvari, ukupni instalisani kapacitet za proizvodnju električne energije bi sa sadašnjih (2020. godine) 8,66 GW porastao na 11,22 GW (bez planiranih mera na 9,78 GW), pri čemu bi instalisani kapaciteti na OIE uključujući hidroelektrane sa 2,89 GW u 2020. godini porasli na 6,22 GW u 2030. godini umesto na 3,70 GW bez tih mera. Prema prognozi za 2040. godinu, ukupni instalisani kapacitet elektrana u Srbiji bi bio 13,75 GW, od čega više od polovine (7,36 GW) u solarnim elektranama, 3,27 GW u hidroelektranama i 3,12 GW u vetroelektranama.

Prognozirani rast instalisanih kapaciteta solarnih elektrana do 2050. godine bi bio još brži i dostigao 18,50 GW od ukupno 29,86 GW, dok bi instalisani kapacitet hidroelektrana ostao skoro isti (3.39 GW), a instalisani kapacitet vetroelektrana bi narastao na 7,97 GW. Za slučaj da posle 2040. godine bude izgrađena nuklearna elektrana snage 1.000 MW, instalisani kapacitet solarnih elektrana u 2050. godini bi bio za 2,5 GW manji (16,00 GW), pri čemu bi instalisani kapacitet vetroelektrana ostao približno isti (8,01 GW) kao i bez nuklearne elektrane.

in coal-fired power plants until 2030 by 25% in relation to the production of electricity in thermal power plants in 2020 and necessary modernization of the mining sector in order to ensure conditions for the stable operation of existing lignite-fired power plants. For achieving above mentioned targets for the reduction of GHG emissions and for fulfilling obligations that Serbia has on the basis of its membership in the Energy Community in accordance with the EC Decision No. 2022/02/MC-EnC, the INECP anticipates that the share of RES in the gross final energy consumption will increase from 26.30% in 2020 to 33.6% in 2030, while the planned share of RES in electricity production is 45.20 % (in accordance with special obligations that Serbia has undertaken towards the IMF and other creditors), 41.4% in energy used for heating and cooling and 7% in energy from RES in transport.

The energy efficiency is an important area for Serbia because today, energy consumption per the unit of product is 50% higher than the average in the EU member states. Focusing on energy efficiency, especially for households and the economy, seems to be the imperative (researches have shown that 85% of residential buildings in Serbia do not meet minimum energy efficiency requirements). The proposed INECP anticipates that in 2030, the total consumption of primary energy will be 14.69 Mtoe, and the consumption of final energy will be 9.67 Mtoe. This is a significant saving because without the implementation of proposed measures, primary energy consumption in 2030 would reach 17.53 Mtoe from the current (in 2020) 15.08 Mtoe, and final energy consumption would reach 10.91 Mtoe from the current 8.89 Mtoe.

Planned electricity production in 2030 will grow from the current 37.62 TWh (in 2020) to 40.19 TWh instead of 45.89 TWh without planned measures. To achieve this, the total installed capacity for electricity production will be increased from the current 8.66 GW (in 2020) to 11.22 GW (without planned measures, it would be 9.78 GW), while installed RES capacities including hydropower plants would be increased from 2.89 GW in 2020 to 6.22 GW in 2030 instead of 3.70 GW without these measures. According to the forecast for the year 2040, the total installed capacity of power plants in Serbia will be 13.75 GW, of which more than a half (7.36 GW) will be in solar power plants, 3.27 GW in hydropower plants and 3.12 GW in wind power plants.

The forecasted growth of installed capacities of solar power plants until 2050 will be even faster and reach 18.50 GW out of the total of 29.86 GW, while the installed capacity of hydropower plants will remain almost the same (3.39 GW), and the installed capacity of wind power plants will grow to 7.97 GW. In case that after 2040, a 1,000 MW nuclear power plant is built, the installed capacity of solar power plants in 2050 will be by 2.5 GW lower (16.00 GW), while the installed capacity of wind power plants will remain approximately the same (8.01 GW) as without the nuclear power plant.

In order to accelerate the growth of the share of renewable energy, the Government has recently passed the Regulation on the Selection of a Strategic Partner for the Implementation of a Project for the Construction of Self-Balanced Solar Power Plants with the Total Installed Capacity of 1,000 MWAC (1,200 MWDC)

U nameri da ubrza rast učešća OIE, Vlada je nedavno donela Uredbu o izboru strateškog partnera za realizaciju projekta izgradnje samobalansiranih solarnih elektrana ukupne instalisane snage 1.000 MWAC (1.200 MWDC) sa baterijskim sistemima instalisane snage 200 MW i mogućnošću skladištenja 400 MWh električne energije. U opciji sa nuklearnom energijom, nuklearne elektrane snage 1.000 MW se uvode u elektroenergetski sistem posle 2040. godine. Predlog INEKP-a predviđa da do 2050. godine termoelektrane na lignit u potpunosti prestanu da proizvode električnu energiju. a da jedan deo (1.427 MW u varijanti bez nuklearne elektrane, odnosno 745 MW u varijanti sa nuklearnom elektranom) ostane kao hladna rezerva.

Danas je većina postojećih energetskih objekata u Srbiji stara oko 40 godina, imaju približno istu tehnologiju i manje-više zavise od jednog istog izvora. INEKP predviđa da se sigurnost snabdevanja energijom zasniva na diversifikaciji izvora energije, uz primenu različitih tehnologija i različitih uvoznih aranžmana sa ciljem da sistem ni u jednom trenutku ne prekine snabdevanje potrošača. Stabilizacija stope energetske zavisnosti je posebno važan cilj INEKP-a za obezbeđenje sigurnosti snabdevanja energijom. Za razliku od EU, trenutna energetska zavisnost Srbije od uvoza energije je relativno niska (32,0% u 2020. godini) i bez planiranih mera bi u 2030. godini dostigla 35,0% zbog visokog učešća uvoza derivata nafte i prirodnog gasa, a sa merama prema INEKP-u u 2030. godini ne bi trebala da pređe nivo od 41,0%, jer se predviđa sopstvena proizvodnja električne energije dovoljna da zadovolji sve potrebe potrošača uključujući automobile na električni pogon i primenu toplotnih pumpi za grejanje i hlađenje prostora, kao i relativno male viškove (1,4%) za neto izvoz.

INEKP predviđa i razvoj unutrašnjeg energetskog tržišta sa namerom da se u Srbiji stvori potpuno integrisano i funkcionalno tržište energije, omogućuju i slobodan protok energije u okviru zemlje i regionalnog tržišta, a potom kroz Energetsku zajednicu i u Evropsku uniju. Da to postigne, INEKP predviđa izgradnju adekvatne infrastrukture i uklanjanje tehničkih ili regulatornih barijera, imajući u vidu da se time značajno povećava i sigurnost snabdevanja potrošača potrebnom energijom.

Za sve prethodno opisane mere za ubrzanje energetske tranzicije, procenjena ulaganja do 2030. godine za implementaciju pojedinih mera predloženih INEKP-om iznose 27,41 milijardi €, od čega je preko trećine planirana javna pomoć (10,04 milijarde €), a ostatak (63,4%) su sopstvena sredstva (17,37 milijardi €). U planiranoj strukturi troškova dominira ulaganje u energetsku efikasnost u iznosu 18,90 milijardi €, od čega su 7,56 milijardi € javna sredstva, a 11,34 milijarde € sopstvena ulaganja. Ukupni troškovi sprovođenja mera dekarbonizacije (smanjenja emisija GSB i povećanja udela OIE) iznose 3,71 milijardu €, od čega su javna ulaganja 870 miliona €, a sopstvena 2,84 milijarde €. Predlog INEKP-a predviđa da

and with Battery Systems with Installed Capacity of 200 MW and the Possibility of Storing 400 MWh of Electricity. In the option with the nuclear energy, nuclear power plant of 1,000 MW will be introduced into the energy system after 2040. The proposal of the INECP anticipates that by 2050, lignite-fired thermal power plants will completely stop producing electricity, and that one part (1,427 MW in the alternative without the nuclear power plant, or 745 MW in the alternative with the nuclear power plant) will remain as a cold reserve.

Today, most of the existing energy facilities in Serbia are about 40 years old and they have almost the same technology and more or less they depend on the same source. The INECP anticipates that the security of energy supply is based on the diversification of energy sources by means of the use of different technologies and different import arrangements in order to enable constant energy supply of consumers without any interruptions. The stabilization of the energy dependence rate is a particularly important objective of the INECP to ensure the security of energy supply. Unlike the EU, current energy dependence in Serbia on energy imports is relatively low (32.0% in 2020) and without planned measures, it would reach 35.0% in 2030 due to the high share of imports of oil derivatives and natural gas, and with measures, according to the INECP in 2030 it should not exceed the level of 41.0%, because it is anticipated that own production of electricity will be sufficient to meet all requirements of consumers, including electric cars and the use of heat pumps for the heating and cooling of premises, as well as relatively small surpluses (1.4%) for net exports.

The INECP also anticipates the development of the internal energy market in order to create a fully integrated and functional energy market in Serbia that will enable free flow of energy within the country and the regional market, and then, through the Energy Community, to the European Union, as well. To achieve this, the INECP anticipates the construction of adequate infrastructure and the removal of technical or regulatory barriers taking into account the fact that this will also significantly increase the security of energy supply to consumers.

For all previously described measures to accelerate energy transition, estimated investments until 2030 for the implementation of the measures proposed in the INECP amount to EUR 27.41 billion, of which over a third is planned public assistance (EUR 10.04 billion), and the rest (63.4%) are own funds (EUR 17.37 billion). In the planned structure of costs, investments in energy efficiency are dominant, amounting to EUR 18.90 billion, of which EUR 7.56 billion are public funds, and EUR 11.34 billion are own funds. Total costs for the implementation of decarbonization measures (reduction of GHG emissions and increase the renewable energy share) amount to EUR 3.71 billion, of which public funds are EUR 870 million, and own funds are EUR 2.84 billion. The proposal of the INECP anticipates that until 2030, EUR 3.21 billion will be invested in energy security of which EUR 1.34 billion will be public funds, and EUR 1.87 billion will be own funds. Investments for the development of the internal energy market are estimated at EUR 1.49 billion, of which EUR 210 million will be public funds and EUR 1.28 billion will be own funds. For research, innovations, and competitiveness, the INECP

do 2030. godine u energetsku bezbednost bude uloženo 3,21 milijarda €, od čega bi 1,34 milijarde € bila javna, a 1,87 milijardi € sopstvena ulaganja. Ulaganja za razvoj unutrašnjeg energetskog tržišta su procenjena na 1,49 milijardi €, od čega bi 210 miliona € bila javna, a 1,28 milijardi € sopstvena ulaganja. Za istraživanje, inovacije i konkurentnost INEKP predviđa ulaganje 110 miliona €, od čega su 60 miliona € javna, a 50 miliona € sopstvena ulaganja.

Imajući u vidu ulaganja predviđena Strategijom niskougljeničnog razvoja (scenario M2) do 2050. godine (za 27 godina) stiče se utisak da navedeno ulaganje u sprovođenje mera koje predviđa predloženi INEKP do 2030. godine (za 7 godina) znači ambiciozniji poduhvat Srbije preuzet sa ciljem da pokaže njenu posvećenost borbi protiv klimatskih promena i inovativnim tehnologijama u ispunjavanju nacionalnih energetskih i klimatskih ciljeva. Njime su definisani strateški prioriteti razvoja energetike u Republici Srbiji koji obuhvataju povećanje udela OIE u strukturi izvora primarne energije, smanjenje finalne potrošnje energije povećanjem energetske efikasnosti i poboljšanje energetske sigurnosti očuvanjem nezavisnosti u snabdevanju električnom energijom istovremeno smanjujući upotrebu lignita. Predložene mere, aktivnosti i projekti imaju za cilj da neizbežnu energetsku tranziciju u Srbiji učine održivom. Od mera predloženih u INEKP-u se očekuje da deluju pozitivno u pogledu ukupnog održivog razvoja, uz posebnu pažnju posvećenu zaštiti životne sredine i očuvanju prirodnih resursa kao ključnih zahteva Zelene agende EU. ■

Radna biografija autora

Miodrag Mesarović, redovni član Akademije inženjerskih nauka Srbije od 2000. godine. Rođen je 1936. godine u Gornjoj Šatornji, opština Topola, Srbija. Završio je realnu gimnaziju u Aranđelovcu 1957. godine. Diplomirao je na Odseku za tehničku fiziku Elektrotehničkog fakulteta u Beogradu 1961. godine, a doktorirao na Mašinskom fakultetu u Beogradu 1978. godine iz oblasti kompjuterske simulacije nestacionarnih procesa sa promenom faza radnog medijuma u termoenergetskim postrojenjima.

Od 1962. godine do danas Miodrag Mesarović radi u Energoprojektu u Beogradu, gde je prošao razvojni put od projektanta do glavnog inženjera, pomoćnika direktora i specijalnog savetnika. Učestvovao je u više stotina privrednih projekata u zemlji i inostranstvu iz oblasti energetike i energetskih tehnologija, kao i u brojnim naučno-istraživačkim projektima o specifičnim problemima u termoeneregetici, nuklearnoj tehnologiji, informatici, zaštiti životne sredine i drugim oblastima. Uz rad se stalno usavršavao i boravio na više specijalizacija u inostranstvu (u Nemačkoj, Švedskoj, Holandiji, Francuskoj i Austriji). Razvio je softverske alate za projektovanje i sigurnost nuklearnih reaktora, za dimenzionisanje i radne karakteristike rashladnih tornjeva i za druge svrhe.

Miodrag Mesarović je generalni sekretar Srpskog komiteta WEC (World Energy Council), predsednik Naučnog odbora Društva termičara Srbije, član Borda i Grupe EuroCASE za upravljanje Energetskom platformom Evrope, koordinator Međuodeljenjskog odbora za energetiku AINS i član Akademijskog odbora SANU za energetiku. Biran je za člana više radnih tela Privredne komore Beograda, Zajednice jugoslovenske elektroprivrede, Saveza energetičara Srbije, Saveta Mašinskog fakulteta u Beogradu, i dr. Učestvovao je kao član ili koordinator više ekspertskih timova, formiranih za izradu predloga strategija razvoja privrede i energetike na nivou države (Strategija privrednog razvoja Srbije, Program ostvarivanja Strategije razvoja energetike Srbije), ili lokalnih samouprava (Strategija razvoja energetike grada Beograda, Strategija razvoja energetike grada Kragujevca i drugih). Imenovan je u više ekspertskih timova zaduženih za praćenje i nadzor državnih projekata (za energetsku efikasnost u Ministarstvu nauke i tehnološkog razvoja Srbije, za sanaciju i odlaganje isluženog nuklearnog goriva i radioaktivnog otpada u Saveznom Ministarstvu privrede, za obnovljive izvore energije i primenu kogeneracije u Ministarstvu rudarstva i energetike Srbije, i drugih).

Miodrag Mesarović je biran za nastavnika na poslediplomskim studijama na mašinskim fakultetima u Beogradu (Optimizacija procesa u termomehanici) i Sarajevu (Uticaj termoelektrana na životnu sredinu) i za člana komisija za odbranu doktorata na Fakultetu strojarstva i brodogradnje Sveučilišta u Zagrebu (Prenos toplote sa zagrejanog rečnog toka) i na Elektrotehničkom fakultetu Univerziteta u Skoplju (Dugoročno planiranje elektroenergetskih sistema) i magistratura na Fakultetu Evropskog centra za mir i razvoj Univerziteta UN za mir u Beogradu.

Učestvovao je na velikom broju stručnih i naučnih skupova u zemlji i inostranstvu i publikovao preko 360 stručnih i naučnih radova iz oblasti strateškog planiranja, nuklearne i termoenergetike, primene obnovljivih izvora energije, zaštite životne sredine, globalnih promena klime, pouzdanosti složenih sistema, akumulacije energije, tehnološkog razvoja, i drugih oblasti. Koautor je šest monografija Svetskog saveta za energiju o nuklearnim elektranama, klimatskim promenama, energetskim resursima i održivosti, i univerzitetskog udžbenika o planiranju razvoja elektroenergetskih sistema u regulisanom i neregulisanom okruženju. Član je uređivačkih odbora više časopisa (“Contemporary Energy“, “Nuclear Technology and Radiation Protection”, “Tehnička dijagnostika” i „Elektroprivreda“) i stalni recenzent u više međunarodnih i domaćih časopisa. Recenzirao je i više naučnih knjiga i monografija. Za uspehe u radu je odlikovan (Orden rada sa zlatnim vencem 1982. godine), nagrađivan (nagrade Energoprojekta 1971. i 1994. za uvođenje naučnog pristupa u projektnu delatnost i 2016. godine za životno delo) i pohvaljivan (povelja i plaketa “Nikola Tesla” Zajednice jugoslovenske elektroprivrede 1993, povelja Društva termičara Srbije 2016, povelja i plaketa Društva za KGH Saveza inženjera i tehničara Srbije 2016. godine).

anticipates the investment of EUR 110 million, of which EUR 60 million are public funds and EUR 50 million are own funds.

Taking into account the fact that investments anticipated by the Low-Carbon Development Strategy (scenario M2) until 2050 (in 27 years), the impression is that the mentioned investment in the implementation of the measures anticipated by the proposed INECP until 2030 (in 7 years) means a more ambitious venture by Serbia undertaken with the aim to demonstrate its commitment to the fight against climate changes and to innovative technologies in meeting national energy and climate objectives. It defines the strategic priorities of the energy development in the Republic of Serbia, which include increasing the share of RES in the structure of primary energy sources, reducing final energy consumption by increasing energy efficiency, and improving energy security by preserving independence in electricity supply while at the same time reducing the use of lignite. The proposed measures, activities and projects are aimed at making the inevitable energy transition in Serbia sustainable. With reference to measures proposed in the INECP, they are expected to act positively in terms of overall sustainable development, with the special attention given to the environmental protection and the preservation of natural resources as key requirements of the Green Agenda of the EU. ■

Work biography of the author

Miodrag Mesarović has been a full member of the Academy of Engineering Sciences of Serbia (AESS) since 2000. He was born in Gornja Šatornja, Municipality of Topola, Serbia in 1936. He graduated from the Real Grammar School in Arandjelovac in 1957. He graduated from the Department of Technical Physics of the Faculty of Electrical Engineering in Belgrade in 1961, and he got his Doctorate Degree from the Faculty of Mechanical Engineering in Belgrade in 1978 in the field of Computer Simulation of Non-Stationary Processes With Phase Change of an Operating Medium in Thermal Power Plants.

From 1962 to the present, Miodrag Mesarović has been working in “Energoprojekt”, Belgrade, as a designer, a chief engineer, an assistant director, and a special advisor. He has participated in hundreds of economic projects in the country and abroad in the field of energy and energy technologies, as well as in numerous scientific and research projects on specific problems in thermal energy, nuclear technology, informatics, environmental protection, and in other fields. Along with his work, he has constantly developed professionally, and he has attended several specialization courses abroad (in Germany, Sweden, the Netherlands, France, and Austria). He has developed software tools for the design and safety of nuclear reactors, for sizing and operating characteristics of cooling towers, and for other purposes.

Miodrag Mesarović is the General Secretary of the Serbian Committee of the WEC (World Energy Council), Chairman of the Scientific Committee of the Society of Thermal Engineers of Serbia, Member of the Board and of the EuroCASE Group for the Management of the Energy Platform of Europe, the Coordinator of the Interdepartmental Committee for Energy of the AESS and the Member of the Academic Committee for Energy of the Serbian Academy of Sciences and Arts. He has been elected as the member of several working bodies of the Belgrade Chamber of Commerce, the Union of the Yugoslav Electricity Industry, the Association of Energy Sector Specialists of Serbia, the Council of the Faculty of Mechanical Engineering in Belgrade, etc. He has participated as a member or as a coordinator of several expert teams that are formed for the preparation of proposals for development strategies for the economy and for the energy sector at the national level (Economic Development Strategy of Serbia, Program for the Implementation of the Energy Sector Development Strategy of Serbia), or at the level of local governments (Energy Development Strategy of the City of Belgrade, Energy Development Strategy of the City Kragujevac, etc.). He has been appointed to several expert teams in charge of monitoring and supervising state projects (for energy efficiency by the Ministry of Science and Technological Development of Serbia, for the remediation and disposal of used nuclear fuel and radioactive waste by the Federal Ministry of Economy, for renewable energy sources and the use of cogeneration by the Ministry of Mining and Energy of Serbia, etc.).

Miodrag Mesarović has been elected as a lecturer at the postgraduate studies at the faculties of mechanical engineering in Belgrade (Optimization of Processes in Thermal Mechanics) and in Sarajevo (Impact of Thermal Power Plants on the Environment) and as the member of the commission for the defense of doctoral thesis at the Faculty of Mechanical Engineering and Shipbuilding of the University of Zagreb (Heat Transfer from Heated River Flow) and at the Faculty of Electrical Engineering of the University of Skopje (Long-Term Planning of Power Systems) and for the defense of master’s thesis at the Faculty of the European Center for Peace and Development of the UN University for Peace in Belgrade.

He has participated in a large number of professional and scientific meetings in the country and abroad and he has published over 360 professional and scientific papers in the field of strategic planning, nuclear and thermal energy, use of renewable energy sources, environmental protection, global climate changes, reliability of complex systems, energy accumulation, technological development, and in other fields. He is the co-author of six World Energy Council Monographs on Nuclear Power Plants, Climate Changes, Energy Resources and Sustainability, and the university textbook for Planning the Development of Power Systems in Regulated and Unregulated Regions. He is the member of editorial boards of several magazines (“Contemporary Energy”, “Nuclear Technology and Radiation Protection”, “Technical Diagnostics” and “Electricity Industry”) and the permanent reviewer in several international and domestic magazines. He has also reviewed several scientific books and monographs. For his work achievements, he has been awarded the Order of Labor with a Golden Wreath in 1982, “Energoprojekt” awards in 1971 and 1994 for the introduction of a scientific approach to design activities, and for Life Achievements in 2016, and he has also been commended (Charter and Plaque “Nikola Tesla” by the Association of Yugoslav Electricity Industry in 1993, Charter of the Association of Thermal Engineers of Serbia in 2016, Charter and Plaque of the Society for Heating, Refrigeration and Air Conditioning of the Union of Engineers and Technicians of Serbia in 2016).