Baština Akademije nauka i umjetnosti Bosne i Hercegovine

# Budućnost postojećih i novih termoelektrana u Bosni i Hercegovini u energetskoj tranziciji

**Hanjalić, Kemal; Smajević, Izet; Musić, Mustafa**

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# BUDUĆNOST POSTOJEĆIH I NOVIH TERMOELEKTRANA U BOSNI I HERCEGOVINI U ENERGETSKOJ TRANZICIJI

AKADEMIJA NAUKA I UMJETNOSTI BOSNE I HERCEGOVINE
АКАДЕМИЈА НАУКА И УМЈЕТНОСТИ БОСНЕ И ХЕРЦЕГОВИНЕ
ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA

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# PERSPECTIVES OF THERMAL POWER IN BOSNIA AND HERZEGOVINA IN ENERGY TRANSISTION

Regional Conference, Sarajevo, 21 November 2019

*Editors:*
K. Hanjalić, I. Smajević, M. Musić

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# 1. PREDGOVOR / PREFACE

Bosna i Hercegovina prihvata načelno globalna opredjeljenja i proklamovane ciljeve relevantnih međunarodnih institucija (Pariški Sporazum, Evropski Zeleni Plan, i drugi) za prelaz na održivi niskougljenični razvoj baziran na kružnoj ekonomiji neuslovljenoj upotrebom prirodnih resursa, te težnju ka nultoj neto emisiji stakleničkih gasova. U energetskom sektoru to podrazumijeva povećanje energijske efikasnosti, te bezuvjetni prelaz na obnovljive izvore energije i eliminaciju fosilnih goriva. I dok je opšte opredjeljenje nesporno, način i dinamika ostvarenja pojedinih ciljeva u zacrtanom roku do 2050. godine sa najmanje negativnih ekonomskih, socijalnih, sigurnosnih i političkih posljedica predstavlja ozbiljni izazov, posebno u zemljama koje se, kao Bosna i Hercegovina, tradicionalno oslanjaju na sopstveni ugalj kao primarni energent.

U cilju doprinosa iznalaženju optimalnih rješenja u energetskoj transformaciji, a u okviru Plana rada za 2019 godinu, Odbor za energiju, energetiku i okoliš (OEEO) Akademije nauka i umjetnosti Bosne i Hercegovine (ANUBiH) u saradnji i uz finansijsku podršku JP Elektroprivreda Bosne i Hercegovine d.d. Sarajevo, je organizovao regionalnno naučno-stručno savjetovanje: *Budućnost postojećih i novih termoelektrana u BiH u energetskoj tranziciji*, koje je održano 21. 11. 2019. godine u ANUBiH u Sarajevu. Cilj Savjetovanja je bio da nauka i struka, pod pokroviteljstvom i u okviru ANUBiH, u saradnji sa stručnjacima iz EU i Regije razmjene iskustva, stavove i planove o upotrebi uglja i biogoriva u proizvodnji električne i toplinske energije u periodu do 2050. godine. Na Savjetovanju, kojem su prisustvovali predstavnici vlasti i zvaničnih institucija iz BiH, naučni radnici, stručnjaci, menadžmenti elektroprivrednih organizacija iz oba bh. entiteta, je na bosanskom, srpskom, hrvatskom ili engleskom jeziku na prethodno odabrane teme izloženo 15 referata po pozivu. Pored stručnjaka iz BiH, referate su podnijeli i pozvani eksperti iz zemalja EU i okruženja sa elektroprivrednom strukturom i izazovima u toj oblasti sličnim kao što ih ima i BiH, a koje u proizvodnji električne energije karakteriše značajni, ili čak dominantni oslonac na fosilna goriva, naročito ugalj. U referatima su izloženi mogući modeli tranzicije i iskustva iz BiH, Srbije, Grčke, Sjeverne Makedonije, Poljske i Njemačke. Prošireni sažeci i slide prezentacije svih referata na jezicima na kojima su referati izloženi, kao i Zaključci Savjetovanja su sadržani u ovom Posebnom izdanju ANUBiH.

Savjetovanje je potvrdilo da je dekarbonizacija elektroenergetskog sektora u EU i Regiji do 2050. godine opravdan, ali i veoma zahtjevan cilj. Svaka država koja se obavezala za takav cilj, mora razviti svoj model održive tranzicije, koristeći vlastito znanje, pomoć eksperata EU, te iskustva i modele drugih. U tom smislu zaključeno je da je veoma važno u što je moguće kraćem roku, u saradnji sa Energetskom zajednicom, detaljno i odgovorno koncipirati razvoj energetskog sektora u Bosni i Hercegovini u tranzicijskom periodu, dajući pritom do znanja Evropskoj uniji, ali i svima drugima, da je Bosna i Hercegovina spremna pratiti i ispoštovati generalno postavljene ciljeve u toj oblasti, uvažavajući pri tom svoju potrebu za energetskom neovisnošću. U tom cilju potrebno je definirati jasnu viziju, sa prohodnim putem do postavljenih ciljeva, uzimajući u obzir sve relevantne direktive i regulativu EU, ali i realne mogućnosti i potrebe Bosne i Hercegovine.

Iskustva i poruke izložene u referatima, diskusije tokom Savjetovanja, te saznanja do kojih smo došli, a koji su sumirani u Zaključcima ovog dokumenta, čine korisnu bazu i orijentir za konkretizaciju strategije za aktuelnu tranziciju energetskog sektora BiH.

Sarajevo, 20. 9. 2020. godine

Predsjednik Odbora za EEO
Akademik Kemal Hanjalić

## 2. REFERATI: PROŠIRENI SAŽECI / PAPERS: EXTENDED ABSTRACTS


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## SJEDNICA I / SESSION I

Energetska tranzicija u EU: iskustvo zemalja EU tradicionalno oslonjenih na ugalj
Energy transition in EU: experiences in EU countries traditionally relying on coal

# ELECTRICITY MARKET GERMANY, VOLATILE RENEWABLES VS. DISPATCHABLE UNITS

**José Gomes*[1], Ronald Rost[2]**

[1] Dornier Group Holding GmbH, Corporate Development, Charlottenstr. 18, 10117 Berlin, Germany
[2] VPC GmbH/ Sales Department, Charlottenstr. 18, 10117 Berlin, Germany
*jose.gomes@vpc-group.biz

This presentation gives an overview of the effects of Wind- and Solar power plants on a fleet of dispatchable power plants that have to follow the power generation in order to close the gap between the real demand and delivery by wind and solar energy at any time. After a short introduction of the Dornier Group, a brief overview is also given of the German electricity exchange trading and the price effects of renewable energies upon it. Further on, it is explained what should be observed by a participating dispatchable power plant in this market. The second half of the presentation provides some details of the production structure of wind- and solar energy in Germany. Some possibilities are shown of how to cope with large quantities of renewable energy that requires flexibility from dispatchable power units.

The presentation shows that wind and solar energy in Germany have a very complementary structure on a daily production basis. Wind energy is dominating during autumn and winter while during spring and summer (April – September) it is the solar energy that prevails. Further on, the statistics of daily distribution of wind and solar energy over the year 2018 shows that more than 98% of the energy out of wind and solar was produced at a rated power of below 50% of the installed power capacity of wind energy. This shows that extreme generation power output values during very specific weather conditions are too limited in order to have a significant economic impact. The same goes for to the so-called “surplus” electricity which lasted only 134 hours in 2018. All this shows that the electricity supply out of wind and solar energy should be divided in a “regular output” and an “extreme value” output. The regular output during approximately 325 days in 2018 is subject to the electricity market, while the remaining 40 days with very high or very low output of wind and solar energy should be handled by the Transmission System Operator (TSO).

The outlook given to the future German electricity market by 2035 predicts approximately 80% of yearly energy out of wind and solar, with 110 GW of capacity each. The simulation of such an installation by using the same wind statistics as of 2018 and assuming further repowering of nearly 70% of the present wind energy installation, shows that a future system would not need more storage than already installed in Germany with 44 GWh of storage capacity and 8 GW of power capacity. Even with this total of 220 GW installed, it can be expected that 94% of the electrical energy generated during one year will be available below 66 GW (60% of the installed wind energy capacity) of active power output. Only the remaining 6% will be available above 66 GW, but only 2% of the yearly energy output will probably be subject to curtailment.

Such a renewable power system in 2035 will consist, in addition to 110 GW of wind and 110 GW of solar power, also of dispatchable units of approximately 70 GW in total. Out of this 70 GW approximately 50 GW will sell their energy into the “energy only market” and will always deliver complementary to the wind- and solar power output with a power range between 1-50 GW according to the gap to be covered between demand and solar and wind output. For mostly 8.260 hours/a this will be sufficient. Only during the remaining 500 hours/a additional (up to) 20 GW of short-term capacity may have to be activated in addition to the above mentioned 50 GW of dispatchable units in order to cover the demand.

It is doubtful that this 20 GW would be part of an “energy only market”. We believe that this kind of short term capacities will deliver either into a capacity market or that they will be

part of grid operators balancing capacities in order to balance out the demand at any time, also beyond the markets deliveries that does not cover extreme values. Currently the German TSOs are already operating 10 GW of short-term dispatchable units in order to provide balancing power if needed. Our analysis shows that this should be doubled if the market is not going to deliver more than 50 GW of dispatchable power.

However, the TSO will not deliver into the market with own capacities. The TSOs power generation serves only for balancing power and for market shortages if needed and is therefore only part of grid operation. It will not compete on the energy market. We expect that a power supply system working under these conditions would be the most viable one.

**Key words:** Flexibilization, Merit Order, Merit Order effect, German electricity market, future electricity market, Dornier Group,

# IMPACT OF EU ENVIRONMENTAL REGULATIONS ON ENERGY SECTOR TRANSITION

**Michał Jabłoński**

Polish Power Plants Association (TGPE), Chalubinskiego 8, Warsaw, Poland
*michal.jablonski@tgpe.pl

Environmental and climate policies are one of the main factors affecting the coal-based energy sector. Poland joining to the European Union in 2004 had to adapt its legal regulations to meet EU requirements while modernizing conventional generating units.

In the last 12 years share of lignite & coal in power installed in Poland decreased by 11 % while share of renewable energy sources (RES) is still increasing (19,2% currently). Especially installed capacity of photovoltaic panels increased by more than 80% year-to-year (above 1 GW in 2019). Also the share of imports in covering domestic energy needs is increasing and Poland notice records in imports of electricity, coal and gas. Greenhouse gases (GHG) emissions only in the Energy sector remained unchanged in the last year. What is important, due to increasing share of unstable RES (wind) the annual maximum peak power demand in the Polish system is growing - in 2018 it reached a new record level of 26.45 GW – especially in summer (low winds & high demand).

In parallel, for last 15 years emission limit values (ELVs) were dramatically lowered for key pollutants - $SO_2$, NOx, dust. To make transition of energy sector as easy as possible, Poland first of all negotiated special provisions in Accession Treaty (2004) for energy & industry sectors - 6 years to adapt integrated permit system based on Best Available Techniques (BAT) and $SO_2$, dust and NOx derogation up to 2017 (with decreasing total cap). In meantime EU strengthened environmental requirements – f.e. with Industrial Emissions Directive (IED) and BAT. During the negotiations energy sector support government with data, experts and knowledge. In effect limited lifetime derogations, transition plans, district heating, BAT derogations and other tools appeared in EU legislation.

Generally, two trends should be noted – extremely strict new plants requirements and less demanding requirements for peak-load plants (1500 h/y). However, to fully use possibility of higher emission for peak plants (mostly used for balancing RES) economic mechanisms to compensate such a short time operation should be adapted – what is very hard due to EU public aid regulations.

Currently EU energy sector is in BAT adaptation process – new requirement have to be met in 2021. Adoption of new limits was controversial – Poland decided to fill a complaint to the European Court of Justice and pointed i.a. incorrect selection of data to tighten ELVs, preference for lower periodic measurement results over higher results from continuous monitoring, not taking into account the specificity of fluidized bed boilers and specifics of the peak plant operation.

Most challenging for Polish energy sector (esp. lignite) were NOx limits, forcing to install secondary denitrification methods and mercury reduction – installation of dedicated mercury reduction techniques. Estimation of costs shown c.a. 2 bln EUR CAPEX needed, with high black out risk (due to lack of necessary reserves to withdrawal in order to meet BAT in 4 years).

Limits for new plants (with NOx lower than 85 mg/m3 and mercury lower than 4 $\mu g/m^3$) affected plants, that were under construction. Changing environmental requirements during investment process forced to redesign flue gas cleaning methods – and install SCR with combined mercury reduction system. Block 7 PGE Turów Power Plant will be first unit in the

world that will met such low emission values with so demanding lignite parameters. Total costs of investment (with net rated power - 446 MWe) is c.a. 800 mln EUR.

Raising share of RES will force to completely redesign energy market. Predictions of energy demand in Poland shows that for peak plants there will be almost no space in merit order in winter, and some space in summer (with average wind generations). Such short working hours will have to cover operating costs. Moreover, almost all traditional power plants will have to be closed down for the weekends. Because of lack of reliability of wind turbines in summer (long periods of no-wind generation on large parts of central Europe) and high demand during the heatwaves system operator notice record high power demand year to year. Therefore, it is necessary to maintain conventional units in system, because imports may not cover the demand. This is mostly economic challenge.

Polish experience in energy sector transition shows, that technology is not a problem. Even most strict environmental requirements are achievable. But this is affecting investment profitability, increases risks and leads to a huge decrease in profitability. Moreover, in the same time $CO_2$ emissions costs (ETS) are rising (up to 60 eur/t in 2040 – or more), what is reflected in energy prices and the economy's competitiveness.

Increasing share of RES is forcing thermal units to work in regulatory regime with extreme various loads – which creating technical and emission problems. Good cooperation with government is the key – emissions limits will be stricter every 6-8 years and economic mechanism have to be adopted, to cover the costs of peak-load and mid-merit plants. Old, end-of-life coal units can be used as peak-load plants and can be competitive with gas units.

**Key words:** BAT, environment, emission, EU

# THE ROLE OF LIGNITE IN THE GREEK ENERGY SYSTEM: FROM THE '50S TILL 2028(?)

**Emmanouil Karampinis[1,2*], Dionysios Giannakopoulos[1], Panagiotis Grammelis[1], Emmanuel Kakaras[1,2]**

[1] Centre for Research and Technology Hellas/Chemical Process and Energy Resources Institute, Egialias 52, 15125 Marousi, Athens, Greece

[2] National Technical University of Athens / Laboratory of Steam Boilers and Thermal Plants, 9 Heroon Polytechniou, 15780 Zografou, Athens, Greece

[*]karampinis@certh.gr

The aim of this work is to present an overview of the role and importance of lignite in the Greek energy system, as well as some prospects regarding its future. Greece is among the top-five EU lignite producers and has huge lignite resources, estimated at 4.6 billion tons, while exploitable reserves are estimated at 2.9 billion tons; its extraction takes place through open-cast mining methods in two main regions: Western Macedonia, corresponding to around 80 % of total production, and Megalopolis in Peloponnese [1].

Greek lignite is one of the poorest fuels utilized in the world, with high contents of moisture and ash. The specific characteristics differ per mining area, but another common feature is the high content of limestone, with mineral $CO_2$ content ranging from 2 to 7 % weight. The CaO in the fly ash contributes to natural desulphurization of the flue gas, but on the other hand has a negative impact on ESP performance [2].

The full cost of lignite is relatively low on a tonnage basis and has been calculated as ranging from 10.65 to 15.58 EUR/t; however, considering its low calorific value, the full cost per energy ranges from 1.94 to 3.74 EUR/GJ, 2.95 EUR/GJ on average, which is higher than many of the other major lignite producing countries, such as Germany, Poland, Czech, Serbia and Bulgaria [3]. This fact has a direct bearing on the electricity generation cost of lignite.

Since the start of large-scale exploitation in the late fifties, lignite has been considered as a key component of the Greek energy system and a cornerstone for the country's energy security. For decades, lignite in Greece is inextricably connected with Public Power Corporation (PPC) S.A., the shares of which are mostly owned by the Greek state. PPC is the only owner and operator of lignite power plants and the major operator of lignite mines (along with a few smaller private producers).

The total installed capacity of lignite-fired power plants of PPC is around 3.9 $GW_e$ (net); almost 80 % of in the installed capacity corresponds to the four operating plants in Western Macedonia with eleven units (Agios Dimitrios I – V, Amyntaio I – II, Kardia I – IV, Meliti I), while the remainder corresponds to the Megalopolis power plant in the Peloponnese (Megalopolis III – IV). Several of these units are quite old, inefficient and already scheduled to be decommissioned in the comings years; however, their connection to local district heating systems remains a complication since alternative heat sources for the networks have not yet materialized.

The share of lignite in the gross electricity generation has fallen from around 70 % in 1990 to 29 % in 2018, losing ground to natural gas and renewables. Rising $CO_2$ prices have seriously affected the profitability of lignite-fired power plants; every increase of 10 EUR/t in the $CO_2$ price corresponds to an increase of 13 to 21 EUR/MWh in the electricity production, see Fig. 1. The situation has promoted the Greek government to announce in September 2019 a coal phase-out by 2028, quite earlier than the expected decommissioning time of some of the currently operating units. In fact, if this deadline is kept, Greece will be the first lignite producing country to phase out coal.

However, a major uncertainty is the fate of the currently constructed Ptolemaida V power plant with an installed capacity of 615 MWe (net), foreseen to be operational within 2021. Despite the fact that it will be the most efficient lignite-fired power plant in PPC's portfolio, it will still have specific $CO_2$ emissions almost double the limit of 550 $gCO_2$/kWh, thus making it ineligible for participation in the capacity market. Along with the rising cost of $CO_2$ allowances, the financial viability of the project is seriously jeopardized, prompting PPC to start an investigation on alternatives for its retrofitting.

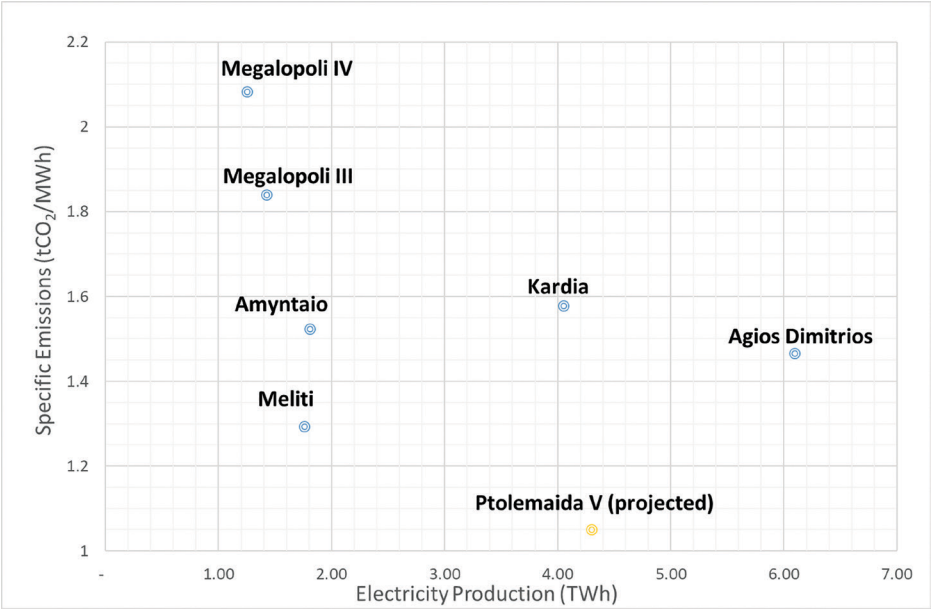



**Figure 1**: Specific $CO_2$ emissions from the lignite-fired power plants in Greece (2017 data)

Overall, the planned lignite phase-out is going to be a major challenge for Greece in the coming years, affecting not the cost of electricity and the energy security of the country, but also the socio-economic balance of the lignite mining areas. Roadmaps and financial support are sought through National and European Just Transition Funds and through participation in initiatives such as the Platform for Coal Regions in Transition.

**Key words:** Greece; lignite; power generation; transition.

## References

[1] EURACOAL: "Coal Industry Across Europe – 6th edition", ISSN 2034-5682, pp. 31-32, 2017.
[2] C. Papanicolaou, M. Galetakis, A.E. Foscolos: "Quality Characteristics of Greek Brown Coals and Their Relation to the Applied Exploitation and Utilization Methods", Energy & Fuels, volume 19, issue 1, pp. 230-239, 2005.
[3] booz&co.: "Understanding Lignite Generation Costs in Europe", 2014.

## SJEDNICA II / SESSION II

Energetska tranzicija u EU: izazovi u zemljama Zapadnog Balkana oslonjenih na ugalj
Energy transition in EU: challenges to Western Balkan countries relying on coal

# TRANSFORMATION CHALLENGES OF THE SERBIAN ENERGY SECTOR

**Miloš Banjac**
University of Belgrade, Faculty of Mechanical Engineering, Department for Thermomechanics, Belgrade, Serbia
mbanjac@mas.bg.ac.rs

The main directions and mechanisms of the EU energy sector transformation are presented through a review of the main goals of the Paris Agreement on climate change, the goals proclaimed by the EU Long-term Energy Strategy by 2050, the ways to achieve these goals as defined by the EU Energy Roadmap 2050, as well as through the new package of EU Directives - Clean Energy for All Europeans. At the same time, based on these EU principles, the current and/or potential requirements of the Secretariat of the Energy Community and the European Commission, which could be imposed on the Serbian energy sector, and which primarily relate to the requirements for increasing the share of RES in final energy consumption, reducing final and primary energy consumption and reducing GHG emissions are presented.

The possibilities of achieving these goals and aligning Serbia with the general EU energy policy have been tested, i.e. checking and analyzing the possibilities of transforming the energy sector of Serbia, in order to maximize its decarbonization, are implemented by using a previously created software for modelling the development of the energy sector, the so-called Serbian Energy Modelling System.

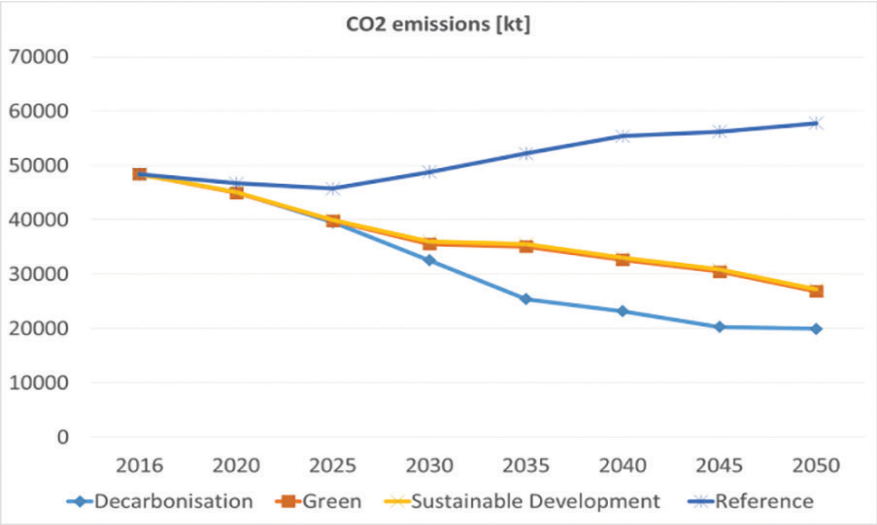



**Figure 1**: Comparison of $CO_2$ emission scenarios

This software is developed based on the commercial software of TIMES Model Generator, and created using statistical data from 2010 to 2017 on the current status and trends of change in Serbia's energy sector, then, based on a large number of official data and official assumptions, such as estimates of industrial growth, the value added projections of industrial sub-sectors, the growth of GDP, the forecasts of changes in average annual growth rate of population, then international projections of fuel price and projections of price of $CO_2$ emissions through Emission Trading Schemes (ETS), then projections of growth of use of renewable energy sources and assessment of the potential for reducing energy consumption by expected technological development, as well by using the official strategic documents of the Republic of Serbia, such as the Energy Development Strategy of the Republic of Serbia until 2025, the Program for the Realization of this Strategy, the National Emission Reduction Plan, etc.

This software tool, operating based on cost optimization criteria, has been used to develop and analyse dozens of possible different scenarios for the development of the energy sector of the Republic of Serbia. Four scenarios, referred to as the Reference Scenario, the Sustainable Development Scenario, the Green Scenario and the Decarbonisation Scenario, identified as four characteristic energy sector development scenarios have been selected and analysed in more detail. Based on the analysis, it has been found that, except for the Reference Scenario, which does not envisage the implementation of $CO_2$ ETS, all other scenarios show that Serbia's energy system has significant potential for decarbonisation (Figure 1). As expected, the most significant consequences of the introduction of the ETS would occur in the electricity sector. Therefore, it would have to react first, by increasing electricity prices, to accommodate the higher costs of its production.

Analysis of the scenario results has shown that with limited operation of thermal power plants, implementation of energy efficiency measures and use of renewable energy sources will play a major role in the decarbonisation of Serbia's energy system. At the same time, regardless of the scenario, it is not realistic to expect that the share of RES in gross final energy consumption will reach binding targets for 2020, nor that in 2030 the targets considered by the Energy Community as potential RES targets for Serbia will be reached. On the other hand, it can be concluded that the so-called energy efficiency targets for final energy consumption will be reached even for 2020, as well as that the targets for total primary energy consumption and final energy consumption for 2030, which the Energy Community considered as potential targets for Serbia, are achievable. In doing so, it has been shown that the combination of energy efficiency measures currently implemented will only stabilize overall primary energy consumption after 2030. Therefore, in the coming period, more attention should be paid to the energy consumption sectors, in order to stabilize the final energy consumption level as soon as possible.

Concerning the dependence on energy imports, which can be considered as the first indicator of energy security, there is an overall tendency that in all scenarios an increase in the total dependence on energy imports can be expected. In particular, an increase in the dependence on natural gas and oil imports can be expected, which is expected due to the expected and inevitable decrease in capacity of domestic resources.

**Key words:** Decarbonisation, Development Scenarios, Energy Roadmap, Strategy

## References

[1] Banjac, M., Ramić, B., Lilić, D., Pantić, A.: Energy in Serbia 2013, The Ministry of Mining and Energy of Republic of Serbia, ISSN 2217-8120, Belgrade, 2015.

[4] Final Report Development of Energy Planning Capacity Project Republic of Serbia, EuropeAid/135625/IH/SER/RS, Contract no: 480000176//2014-28, LDK Consultants Engineers and Planners SA and ΚΑΠΕ CRES, 28 October 2019.

[5] Loulou, R., Remne, U., Kanudia, A., Lehtila, A., Goldstein, G., 2005. Documentation for the TIMES Model, ESTAP, May 2005.

# THE FUTURE OF THERMAL POWER PLANTS - CHALLENGES AND OPPORTUNITIES FOR ENERGY DEVELOPMENT IN NORTH MACEDONIA

**Gligor Kanevce**

Macedonian Academy of Sciences and Arts, Research Center for Energy and Sustainable Development, Bul. Krste Misirkov 2, Skopje, Macedonia
*kanevce@manu.edu.mk

At the end of the 20th century, the Republic of Macedonia met the needs of electricity from its own sources, from which 80% from coal-fired power plants (lignite with low calorific value) and around 20% from hydro power plants. However, starting from 2000, in parallel with the increase in the demand for electricity in the RM, the electricity production from the coal-fired power plants has been declining. The growing gap between electricity needs and electricity production is fulfilled with imports. In the current electricity supply, imports account for about 30%. However, the domestic production is still dominated by coal, at 54%. The electricity production in the coal-fired thermal power plants relies primarily on TPP Bitola and partly on TPP Oslomej. Both are relatively old and face problems with the future coal supply.

In order to identify possible directions for development of the energy system of Macedonia by 2040, three scenarios have been selected as a basis for creating an appropriate strategy: Reference, Moderate Transition and Green [1]. The scenarios reflect different dynamics of the energy transition and enable flexibility of Nord Macedonia's response to relevant EU policies for a modern, competitive and climate-neutral economy by 2050.

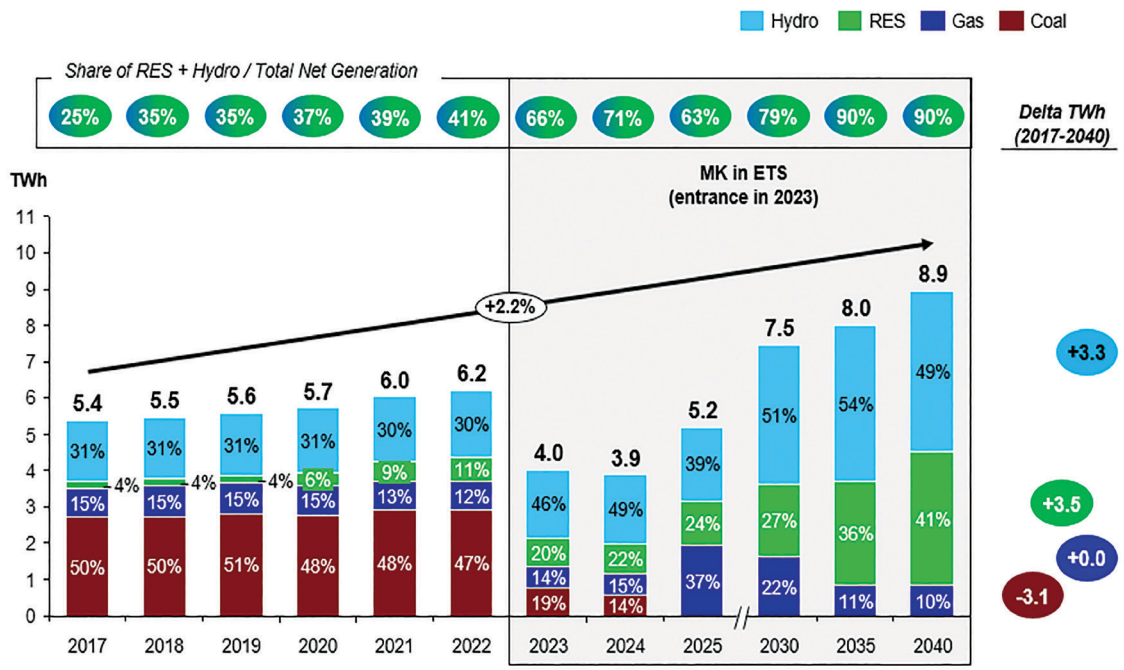



**Figure 1**: Evolution of total net generation mix – Green scenario

The main differences in the scenarios are in the energy efficiency policies that are embedded, RES penetration policies, the expected evolution of $CO_2$ and natural gas prices, as well as in the year when Macedonia will enter the EU ETS. The $CO_2$ and natural gas price estimates are based on the WEO 2017. The Reference scenario relies on the WEO 2017 Current Policy Scenario, the Moderate Transition Scenario on the New Policy Scenario, and the Green Scenario uses the WEO 2017 Sustainable Development Policy Scenario. The modeling of the en-

ergy system development was implemented using the MARKAL software package. The P2S model was used for supplementary analyzes of the electricity sector.

Analyzes have shown that in the Reference scenario, TPP Oslomej is decommissioned while TPP Bitola is renovated and continues to work with reduced capacity. In the remaining two scenarios, both coal-fired power plants are decommissioned in 2025 (Figure 1). The difference to the required amount of electricity is compensated mainly by the construction of new RES (storage HPPs, including one pumped-storage HPP, photovoltaic and wind power plants, small HPPs and small quantities of biogas and biomass power plants) and several small gas fired combined heat and power plants and thermal power plants. In each of the three scenarios, Macedonia reduces the dependence on electricity imports and increases the integration within the European market.

**Key words:** Energy development, Macedonia, Thermal power plants

## References

[1] Strategy for Energy Development of the Republic of North Macedonia until 2040, http://www.economy.gov.mk/Upload/Documents/Adopted%20Energy%20Development%20Strategy_EN.pdf, 2020.

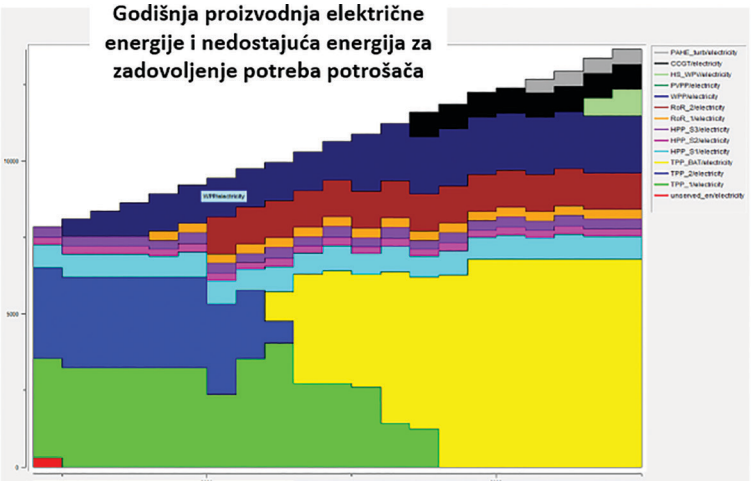
# MODEL SREDNJOROČNOG RAZVOJA PROIZVODNOG PORTFOLIJA BOSNE I HERCEGOVINE DO 2035. S PROJEKCIJOM RAZVOJA DO 2050. GODINE

**Ajla Merzić [1*], Anes Kazagić [1], Mustafa Musić [1], Miroslav Nikolić [2], Zdravko Milovanović [3], Dušan Golubović [4], Petar Gvero [3]**

[1] JP Elektroprivreda BiH d.d. – Sarajevo, Sektor za strateški razvoj, Vilsonovo šetalište, 71000 Sarajevo, BiH
[2] JP Elektroprivreda HZHB d.d. - Mostar, Razvoj, Ulica kralja Petra Krešimira IV, 6-A, 88 000 Mostar, BiH
[3] Univerzitet u Banja Luci, Mašinski fakultet, Banja Luka, Stepe Stepanovića 71, 78000 Banja Luka, BiH
[4] Univerzitet u Istočnom Sarajevu, Mašinski fakultet, Vuka Karadžića 30, 71123 Istočno Sarajevo, BiH
[5] Univerzitet u Banja Luci, Mašinski fakultet, Stepe Stepanovića 71, 78000 Banja Luka, BiH
* a.merzic@epbih.ba

Energetska tranzicija se općenito može definisati kao dugoročna strukturalna promjena energetskih sistema u dekarbonizirane sisteme. Mnoge zemlje Svijeta, prvenstveno one razvijene, definisale su svoje razvojne planove i poduzele sistemske korake ka ostvarenju postavljenih ciljeva dekarbonizacije. S druge strane, zemlje u razvoju, čiji se sadašnji proizvodni portfolio dominantno bazira na upotrebi fosilnih goriva, prvenstveno uglja, nalaze se pred posebnim izazovima u tom pogledu. Takav jedan sistem jeste i sistem Bosne i Hercegovine (BiH), koji je u fokusu ovog članka i za koji je definisan koncept srednjoročnog razvoja do 2035, s projekcijom razvoja do 2050. godine.

U okviru provedenog istraživanja razmatrano je više scenarija upotrebom programskih paketa Međunarodne Agencije za Atomsku Energiju, WASP IV i MESSAGE, s ciljem definisanja odgovarajućih koncepata tranzicije. U ovom članku predstavljeni su rezultati optimiziranog tranzicionog modela koji je uključio smanjenje emisija $CO_2$, povećanje udjela proizvodnih jedinica na obnovljive resurse, s fokusom na intermitentne izvore (prvenstveno vjetroelektrane i fotonaponske elektrane), obezbjeđenje balansne snage za pokrivanje tih varijacija, vrijednost kumulativnih troškova i društvene benefite tranzicije. Slika 1. daje prikaz godišnje proizvodnje električne energije i nedostajuće energija za zadovoljenje potreba potrošača za optimizirani tranzicioni model u razmatranom vremenskom periodu.




**Slika 1**: Godišnja proizvodnja električne energije i nedostajuća energija za zadovoljenje potreba potrošača

U tom pogledu, model je koncipiran da zadovolji odgovarajuću vrijednost indeksa pouzdanosti tj. vjerovatnoće gubitka opterećenja, obezbijedi smanjenje emisija $CO_2$ za najmanje 20% u odnosu na trenutno stanje i omogući visoku penetraciju proizvodnih jedinica na obnovljive

resurse. Prilikom analiza, model je uvažio i integraciju novih termoelektrana na ugalj na najbolje raspoložive tehnologije, odgovarajuće koncepte hibridnih sistema, te fleksibilne proizvodne jedinice za balansiranje intermitentnosti izlazne snage vjetroelektrana i fotonaponskih elektrana.

Predstavljeni model struktuiran je tako da se može primijeniti i na sisteme drugih zemalja čiji je proizvodni portfolio dominantno baziran na uglju, bez obzira na veličinu, pod uslovom da postoje raspoloživi resursi za integraciju proizvodnih jedinica na obnovljive resurse.

Da bi se zadržali postavljeni trendovi i nakon planskog perioda, u ovome radu je pretpostavljena promjena koncepta sa postojećeg prvenstveno centraliziranog sistema u decentralizirani sistem, smanjenje proizvodnje iz fosilnih goriva kroz dalju integraciju obnovljivih resursa, supstituciju uglja sa biomasom u procesu kosagorijevanja, eventualnu potpunu konverziju nekih postojećih termoblokova sa uglja na biomasu, ali i implementaciju novih tehnologija koje podrazumijevaju izdvajanje ugljendioksida iz struje dimnih plinova, njegovo skladištenje i njegovu adekvatnu dalju upotrebu.

**Ključne riječi:** balansiranje snage, dekarbonizacija, energetska tranzicija, model

## Reference

[1] Renewable Energy Policy Network for the 21st century: „Renewables 2018 Global Status Report", 2018.
[2] Jürgen-Friedrich Hake, Wolfgang Fischer, Sandra Venghaus, Christoph Weckenbrock: „The German Energiewende - History and status quo", Energy, Vol. 92, pp. 532-546, 2015.
[3] Y. P. Li, G. H. Huang, M. W. Li: „An integrated optimization modeling approach for planning emission trading and clean-energy development under uncertainty", Renewable Energy, Vol. 62, pp. 31-46, February, 2014.
[4] A. Merzic, M. Music, Z. Haznadar: „Conceptualizing sustainable development of conventional power systems in developing countries - A contribution towards low carbon future", Energy, Volume 126, pp. 112-123, May, 2017.

# USPOSTAVITI SISTEM KORIŠTENJA ZNANJA U RAZVOJU ENERGETSKOG SEKTORA BOSNE I HERCEGOVINE

**Aleksandar Knežević**
IMPULSIO, Pokret za vladavinu znanja, Sarajevo
a.knezevic@impulsio-sarajevo.org

Polazi se od teze da Bosna i Hercegovina danas ne raspolaže ni organizacionim ni ljudskim resursima za planiranje razvoja energetskog sektora na principima vladavine domaćeg znanja. Povjeravanje stranoj instituciji da vrši izradu državne i entitetskih okvirnih energetskih strategija nije neočekivano, ali s planskim i svjesnim isključivanjem domaćih stručnjaka, doživjelo je osudu od strane više univerzitetskih nastavnika, nekih drugih organizacija u BiH, te posebno Odbora za energiju, energetiku i okoliš Akademije nauka BiH, [1].

Kao kontrast navedenom, u radu se veoma kvalitetnim ocjenjuje komponenta energije u strategiji Ekonomske stabilizacije Jugoslavije još iz davne 1983. godine, [2]. Današnji nivo razvoja elektroenergetskog sektora BiH: (i) izgradnja termoelektrane na ugalj (vjerovatno posljednja u Evropi), (ii) potpuno odsustvo sistemskih mjera za povećanje energijske efikasnosti, (iii) bez komponenti građanske energije na području obnovljivih izvora, ukazuje da je BiH na nivou razmišljanja Elektroprivrede BiH iz davne 1985. godine, [3].

Bosna i Hercegovina je najveći rasipnik energije na svijetu, [4]. Ovdje se cijeni da su tri razloga za to: (i) niska energijska efikasnost u industriji i domaćinstvima, (ii) značajan broj energijski visokozahtjevnih industrijskih pogona koji daju nizak profit, te (iii) niska energijska efektivnost vlasti u BiH u konverziji aktivnosti u društveni proizvod države. Mnoge su nepoznanice vezane za projekat Termoelektrane Tuzla, blok 7. Projekat je razvijan u potpunoj ilegalnosti. Nije jasno pitanje obaveze Elektroprivrede BiH prema Vladi FBiH koja je dala garanciju za kredit. Nije jasna izjava Elektroprivrede BiH da će Elektroprivreda BiH u ime dobivanja garancije: (i) Vladi FBiH uplatiti nešto više od 40 miliona KM, (ii) dati pod hipoteku dva vrijedna energetska objekta kao kolateral, te (iii) dati asignaciju na određeni broj velikih kupaca (pravo naplate u periodu od pet godina), [5].

Nije jasno na šta će se utrošiti u BiH jedna trećina kredita kineske Eksim banke [6], ako kineske organizacije isporučuju u potpunost i opremu i rad. Projekat TE Tuzla 7 ne može biti viđen kao tehno-ekonomski projekat jednog bloka bez analize društveno-ekonomske održivosti i to u toku vremena – sve do 2050. godine i prostora (Tuzlanski kanton i cijela država). Projekat ne predviđa troškove kupovine certifikata za emisije po ETS šemi EU, a i mnogi drugi ulazni podaci su dati nekorektno.

U radu se, uz zahtjev prema vlastima da donošenje razvojnih odluka bude transparentno, predlaže – u nedostatku sistema naučnog rada u BiH - više modela *hibridnog* instituta za energiju/energetiku – okolinu/klimu koji bi povezali vlast i javna preduzeća, domaću i stranu struku (pojedince-eksperte i organizacije) u rješavanju problematike razvoja energetskog sistema države/ entiteta.

Predloženo je sedam različitih modela počev od mreže eksperata imenovanih od strane vlasti pa do modela zajedničkih timova domaćih i stranih organizacija. Posebno je razrađen sistem odgovornosti od strane svakog učesnika u projektu – naručioca i izvršioca i to davanjem značaja sistemu kvaliteta i naručioca i izvršioca posla čiji elementi treba da su predmet ugovora. Praksa hibridnih instituta bi doprinijela razvoju domaćeg znanja, odnosno, domaćih institucija, te tako i kvalitetu energetskih strategija i projekata u narednom periodu. Na kraju doprinijela bi povjerenju stručnjaka u rad političara.

Skup u okviru koga je objavljen predmetni rad je treći skup takve vrste koga organizuje Akademija nauka i umjetnosti BiH (prethodni su bili organizovani 2009. i 2016. godine).

Praktično su to jedini relevantni (naučni i stručni) skupovi vezani uz razvoj energetike u Bosni i Hercegovini. Zaključci Skupa koji se očekuju biće jedini *de facto* dokument vezan za razvoj energetskog sistema Bosne i Hercegovine.

## Literatura


[1] Stav o okvirnoj energetskoj strategiji BiH do 2035. godine, Akademija nauka BiH, Odbor za EEO, Sarajevo, 2017

[2] Prilagođavanje privrednog sistema zahtjevima stabilizacije razvoj pravnog sistema sa stanovišta ekonomske stabilizacije, regionalni aspekt razvoja Jugoslavije; strategija i osnove politike razvoja, Deveta sjednica CK SKJ, Sarajevo 1983

[3] Okvirna srednjoročna energetska strategija Bosne i Hercegovine (izvršilac posla autori nisu poznati), Sarajevo 2017

[4] Strategija niskougljičnog razvoja Hrvatske, 2017

[5] http://www.federalna.ba/bhs/vijest/268733/otvoreni-studio-13032019 (18-ta minuta)

[6] Nermin Đindić, Ministar za energiju, industriju i rudarstvo FBiH; Radio BH 1, 1. juni 2019 (zabilježio A. Knežević)

# SJEDNICA III / SESSION III

Eksploatacija postojećih TE: revitalizacija, modernizacija, obustava
Exploitation of existing TPPs: revitalization, modernization, shut downs

# POVEĆANJE SNAGE, EFIKASNOSTI I UVOĐENJE SAVREMENIH TEHNOLOGIJA ZA SMANJENJE ZAGAĐENJA ŽIVOTNE SREDINE U TERMOELEKTRANAMA SRBIJE

**Predrag Stefanović [1*], Dejan Cvetinović [1], Zoran Marković [1], Milić Erić [1]**

[1] Univerzitet u Beogradu, Institut za nuklearne nauke "Vinča", Laboratorija za termotehniku i energetiku
P.p 522, 11001 Beograd, Srbija
*pstefan@vinca.rs

Posle perioda neregularnih uslova rada, maksimalno ograničenih uslova i sredstava za investiciono i tekuće održavanje tokom 90-ih godina XX veka, proizvodna postrojenja u Eleketroprivredi Srbije su početkom XXI veka bila pri kraju projektovanog proizvodnog perioda, imala velike probleme u ostvarenju potrebne proizvodnje, sigurnosti, pouzdanosti, energetske i ekonomske efikasnosti. Posebno su bili izraženi problemi zagađenja životne sredine (vazduha, vodenih tokova i zemljišta) radom termoelektrana na lignit. Proizvodni kapaciteti JP EPS-a (snaga na pragu i procentualno učešće proizvodnje u ukupnoj godišnjoj proizvodnji) bez kapaciteta na KiM, su 2001. godine bili: TE na ugalj: 3936 $MW_e$ (66,1%), TE-TO na gas i tečno gorivo 353 $MW_e$ (1,4%), HE 2831 $MW_e$ (32,5%).

Ratifikacijom Ugovora o Energetskoj zajednici Jugoistočne Evrope, 2006 godine, Republika Srbija je preuzela obavezu da implementira najbolje tehnologije za smanjenje zagađenja iz termoelektrana. Usvojena metodologija realizacije projekata revitalizacije/modernizacije obuhavatala je 3 faze. U prvoj fazi vršene su obimne i složene pripreme kao što su: detaljna analiza rada/otkaza, sistematsko uzorkovanje u cevnom sistemu kotla, analiza naslaga i korozionih oštećenja u uzorcima, procena preostalog veka pojedinih komponenti cevnog sistema/postrojenja, termotehnička merenja parametara rada pojedinih postrojenja, idejno rešenje, tehno-ekonomska analiza opravdanosti investicija u predloženo rešenje kao i izrada tehničke i tenderske dokumentacije za izvođenje (za sve projekte paralelno). U drugoj fazi, realizacija investicionih projekata za revitalizaciju i modernizaciju proizvodnih kapaciteta (uz povećanje snage, efikasnosti i uvođenje najboljih tehnologija za smanjenje emisije), je tekla postepeno, po projektima i blokovima u zavisnosti od stanja i nivoa angažovanja termobloka u proizvodnji, složenosti projekta i nivoa potrebnih investicija. U trećoj fazi, po završetku investicionih radova i uhodavanja modernizovanih postrojenja, vršena su garancijska ispitivanja: Test A i godinu dana kasnije na kraju garantnog perioda Test B, u cilju utvrđivanja ostvarenih efekata.

Tipični primeri ovih projekata su: 1. Povećanje snage dva bloka TEKO B1/B2 svaki nominalne snage 348,5 MW koji su od puštanja 1989/1991. godine imali problema u dostizanju snage iznad 320 MW. Otklanjanje uočenih nedostataka je realizovano u više faza, pre i posle kojih su vršena detaljna ispitivanja: rekonstrukcija/unapređenje ložnog postrojenja, modernizacija sistema napajanja kotla vodom i skidanje ograničenja kapaciteta napojnih pumpi 2002, itd. Detaljna ispitivanja posle remonta 2003. godine su ukazala na mogućnost ostvarenja produkcije pare i do 1150 t/h i snage bloka do 375 MW uz garantovane stepene korisnosti kotla ≥87%. 2. Rad na podizanju snage (na 348,5 MW) i efikasnosti termobloka TENT A6 (308,5 MW) se odvijao u periodu od 2006÷2010 godine sa remontnim radovima 2008 i 2010 godine, [1]. Inicijalna detaljna ispitivanja su ukazala da postoje značajne rezerve na generatoru i blok trafou a da će glavni radovi/investicije biti na kotlovskom i turbinskom postrojenju.

Na kotlovskom postrojenju izvršeni su brojni zahvati u cilju podizanja produkcije pare sa 920 na 1050 t/h uključujući i modernizaciju EF za emisiju <50 mg/$Nm^3$ kao i retrofit TVP, TSP, kompletne ventilske blokove TVP i TSP i unutrašnji modul TNP. Garancijska ispitivanja kotla, EF i turbinskog postrojenja izvršena su početkom 2011 i potvrdila garantovane parametre. 2011 godine TENT A6 je ostvario najduži rad na mreži od 8224 h i od svoje prve sinhronizacije ostvario najveću godišnju proizvodnju od 2484 GWh. Ostvarena je prosečna (na nivou

cele 2011. godine) snaga na mreži od 302 MW. Rezultati rehabilitacije i modernizacije termoblokova jasno su se odrazili na proizvodnju u JP EPS-u (Tabela 1). Ista metodologija je primenjena za podizanje produkcije kotla sa 1880 na 2000 t/h i snage bloka TENT B1 (sa 618,5 na 665,2 MW). Kod blokova TENT A3-A5 podizanje snage (sa 305-308,5 na 328,5-332,8 MW) i energetske efikasnosti je ostvareno pre svega modernizacijom turbinskog postrojenja.

Na termoblokovima JP EPS-a uporedo sa rehabilitacijom, povećanjem pouzdanosti, snage i efikasnosti, vršena je implementacija najboljih tehnologija za smanjenje zagađenja životne okoline (Tabela 2). TE Kolubara A i TE Morava se zatvaraju do 2023. a zamenski je novi blok TE Kostolac B3 (350 MW, bruto/neto stepen korisnosti 42%/37% sa svim merama redukcije emisije PM, NOx i SOx u vazduh).

**Tabela 1.** Proizvodnja uglja i električne energije u TE na ugalj u JP EPS 2001/2011. godine

| | Ukupna proizvodnja uglja Mt/god | | | Potrošnja uglja u TE Mt/god | | |
|---|---|---|---|---|---|---|
| | 2001 | 2011 | Povećanje | 2001 | 2011 | Povećanje |
| Kolubarski basen | 25,334 | 31,061 | 122,6% | 23,378 | 29,355 | 125,6% |
| Kostolački basen | 5,165 | 9,23 | 178,7% | 4,897 | 8,873 | 181,2% |
| PD TE Nikola Tesla | Proizvodnja elektrine energije GWh | | | 16150 | 20205 | 125,1% |
| PD TEKO Kostolac | 2823<br>6257 | | | 221,6% | | |

**Tabela 2.** Primena najboljih tehnologija za smanjenje emisije iz termoblokovima na lignit u JP EPS-u prema EU direktivi LCP 2001/80/EC (bez kapaciteta na KiM)

| JP EPS termoblok na lignit | Elektro filteri | Mere za smanjenje Nox | | Postrojenje DeSOx | Novi sistem transporta pepela | Tretman otpadnih voda |
|---|---|---|---|---|---|---|
| | | Primarne | Sekundarne | | | |
| TENT A1 | 2007 | Planirano za 2022, Investicija 36M€ | | | Zajedničko za TENT A1-A6 2021 65,8 M€ | Zajedničko za TENT A1-A6 |
| TENT A2 | 2006 | Planirano za 2023, Investicija 36M€ | | | | |
| TENT A3 | 2014 | 2014 | | Zajedničko za TENT A3-A6 u izgradnji | | |
| TENT A4 | 2008/18 | 2018 | | | | |
| TENT A5 | 2005 | 2015 | | | | |
| TENT A6 | 2010 | 2010/2020/12,2M€ | | | | |
| TENT B1 | 2012 | 2022/ 12,3M€ | | Zajedničko Invest. 190 M€ | 2012 | |
| TENT B2 | 2011 | 2021/ 12,3M€ | | | | |
| TE Kostolac A1 | 2005 | planirana Investicija 27M€ | | | 2018 | 2022 |
| TE Kostolac A2 | 2008 | 2022/ 10M€ | | 2023./49M€ | | |
| TE Kostolac B1 | 2014 | 2014 | | 2017 | 2014 | 2020 |
| TE Kostolac B2 | 2012 | 2019-2020/ 12,3M€ | | 2016 | | |

**Ključne reči:** povećanje snage i efikasnosti, smanjenje zagađenja, TE na ugalj u Srbiji

## Literatura

[1] Predrag Lj. Stefanović et all, Review of the Investigations of Pulverized Coal Combustion processes in large power plants in laboratory LTE – Part B THERMAL SCIENCE: Vol. 23, Suppl. 5, pp. S1611-S1626, Year 2019.

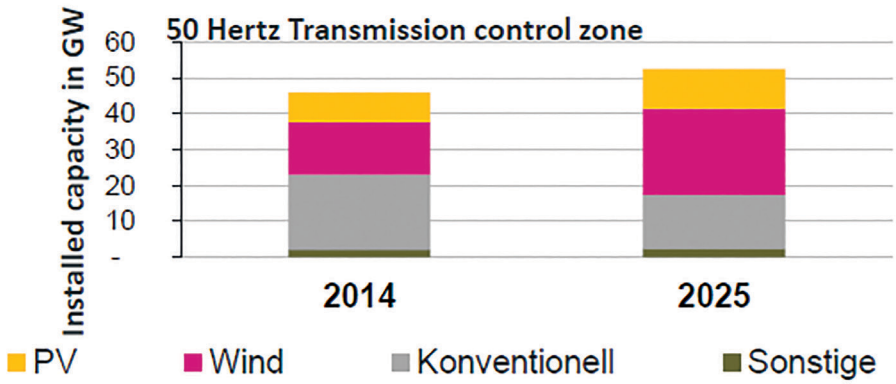
# FLEKSIBILNOST TPP POSTROJENJA, STUDIJA SLUČAJA IZ NEMAČKE

**Ronald Rost[1], Dragomir Markovic[2*], Zoran Bozovic[3]**

[1]VPC Gmbh/V-A Department, Charlotten Strasse 18, 10117 Berlin, Germany, [2,3]VPC-East/Senior Advisors, Kralja Milana 3, 11000 Beograd, Srbija
*dragomir.markovic@vpc-group.biz

Transformacije elektroenergetskog sektora u pravcu intenziviranja razvoja i primene obnovljivih izvora energije su započele pre više od dvadeset godina. Globalno zagreavanje i čitav niz ekološki negativnih uticaja korišćenja fosilnih goriva uslovljavaju sledeće korake u procesu prelaska sa TPP na obnovljive izvore energije:

- Modernizacije postojećih termoelektrana (povećanje efikasnosti i primena BAT tehnologija, rekonstrukcije sistema za smanjenje emisija štetnih materija u skladu sa aktuelnom regulativom, upravljanje kvalitetom goriva, kombinovano loženje itd.
- Izgradnja BAT zamenskih kapaciteta (prioritetno na loženje prirodnim gasom) za stara i neefikasna postrojenja.
- Ubrzana primena obnovljivih izvora energije uz državne podsticaje srazmerno energetskim raspoloživim potencijalima uz postepeno limitiranje prethodnih koraka.
- Osposobljavanje postojećih termoelektrana za pružanje sekundarnih servisa (fleksibilnost, primarna i sekundarna regulacija…) do kraja svog veka (2030–2040).
- Intenziviranje energetske efikasnosti u transportu i potrošnji energije itd.




**Slika 1**: Struktura proizvodnih kapaciteta u Nemačkoj regulatornoj oblasti "50 Hertz"

Efekti sistema na rad konvencionalnih postrojenja se ogledaju u sve većem broju ekstremnih situacija sa proizvodnim pikovima, smanjenje kontinuirane proizvodnje, sve veće intervencije re-dispach i pad cena na tržištu. Evidentno smanjenje proizvodnih kapaciteta na lignit i ugalj u Nemačkoj kao posledica tržišne politike uslovljene zahtevima zaštite životne sredine uslovljava potrebu termoelektrana da povećaju fleksibilnost i ponude dodatne servise sistemu kako bi produžile svoj vek na tržištu.

VPC GmbH je pripremio tzv, Flege program koji je primenjen na elektrane u sastavu nemačkog Vattenfalla. Osnovni zahtevi za postrojenja su:

- Povećanje broja startovanja i zaustavljanja
- Brzina promene opterećenja uz još uvek visoku efikasnost
- Smanjivanje minimalnog opterećenja bez podrske tečnim gorivom
- Skraćenje vremena startovanja

Prezentacija sadrži tri studije slučaja iz Nemačke prakse. Prvi primer se odnosi na TPP Jaenschwalde (6x500MW), na lignit, izgrađena osamdesetih. Postignuti su sledeći rezultati:

- Prepolovljeno minimalno tehničko opterećenje: od 180 MW do 90 MW
- Sprečavanje gašenja i pokretanja postrojenja povezanih sa uticajem mreže i skraćenja radnog veka i većih troškova održavanja
- Zamena tečnog goriva sa suvim lignitom.
- Povećanje gradijenta opterećenja na +/- 8 MW/min sa nivoa 2-3 MW/min

Drugi primer se odnosi na novu USC TPP Moorburg (2x827 MW), kameni ugalj. Rezultati:

- Smanjenje tehničkog minimuma sa 35% (vezano za količinu sveže pare) na 26%
- Rad postrojenja osiguran u režimu čistog uglja, tj. bez dodatnog loženja ulja ili upotrebe pomoćnih generatora pare: garantovano 24% (u testovima postignuto i 20%)
- Povećanje gradijenta opterećenja tokom rada na +/- 34MW/min
- Skraćivanje vremena pokretanja za 30 min (topli start) itd.

Treći primer se odnosi na optimizacije CCGT CHP Lepzig snage 172 $MW_e$/180 $MW_{th}$:

- Povećavanje operativne fleksibilnosti na +/- 30 MW/min
- Povećanje efikasnosti za 1,5% snage / ukupno 3%
- Pružanje primarne upravljačke snage +3,5 MW i +30 MW sekundarne snage

Dodatno smo prikazali strukturu regionalne elektroenergetske upravljačke oblasti SMM-EMS (Srbija, Severna Makedonija, Crna Gora) sa kapacitetom cca. 10 GW. Detaljnije smo obradili karakteristike elektroenergetskog sistema Srbije sa prikazom raspoloživim kapacitetom za sekundarnu regulaciju. Takođe, upućujemo na podršku VPC GmbH u procesu unapređenja sledećih TPP karakteristika na bazi pozitivnih referenci iz Nemačke. Fleksibilnost starih termoelektrana (posebno onih dizajniranih za bazna opterećenja) zahteva veoma pažljiv i sistematski pristup sto podrazumeva:

- Studija izvodljivosti, koncept, osnovni i detaljan dizajn svih sistema
- Nadzor, puštanje u pogon, operativnu dokumentaciju postrojenja itd.
- Ključni zahtevi za termoelektrane: Povećavanje broja procesa pokretanja i gašenja, Promena brzine opterećenja sa još uvek visokom efikasnošću, Smanjenje minimalnog opterećenja bez potpore lož-ulja, Skraćivanje vremena pokretanja itd.
- Analiza rizika npr:

- Procesi ubrzane razgradnje materijala usled cikličkog opterećenja: puzanje i zamor,
- Sveobuhvatni proračun stvarnih troškova regulacije (uključujući EFOR), itd.

**Ključne reči:** fleksibilnost, obnovljivi izvori, sekundarna rezerva, termoelektrane

## Reference

[1] Commission Regulation (EU) 2017/1485 Guideline on electricity transmission system operation of 2 August 2017
[2] José Gomes, Electricity market Germany - Renewables vs. Dispatchable Units - ANUBIH, Sarajevo 21. Novembar 2019.
[3] Vattenfall Presentation, VGB PowerTech 01/02 2018
[4] Tehnički Izveštaji i Studije JP EMS i JP EPS 2010-2018

# MEGATRENDS IN THE EUROPEAN ENERGY SECTOR AND THEIR IMPACT ON THE TRANSITION OF THERMAL POWER PLANTS TOWARDS A SUSTAINABLE MODEL UNTIL 2050

**Grzegorz Kotte**

COO, Technical Director of Kozienice Power Plant
Enea Wytwarzanie Sp. z o.o., Świerże Górne, Aleja Józefa Zielińskiego 1, 26-900 Kozienice, Poland
grzegorz.kotte@enea.pl

Due to the aging energy production infrastructure and climate change legal requirements set by the European Union, energy companies need to take decisions regarding future development strategies. This presentation will show where Polish energy production will be heading in the next 20 – 30 years.

The first part of this presentation discusses megatrends in the European energy production, considered to be very influential social, economic, technological or political phenomena that affect the societies, governments and economies of many countries, which cannot be ignored. These energy megatrends are on one hand a challenge, but on the other hand, if taken seriously and with due attention, can also be an opportunity for business, innovation, labour market and improvement of the environment.

The second part of the presentation will tackle the modernization strategies of the Kozienice Power Plant, which is the largest Polish hard coal power plant, aimed at increasing the energy efficiency and adapting the plant to meet the current and near-future European and international emission regulations and requirements. These include primarily the Large Combustion Plants Directive, the Industrial Emission Directive and the Best Available Techniques (BAT) standards.

The final part will address modernization strategies of the Polish energy sector by 2040 based on the Polish Energy Policy, and their impact on the policies of Polish energy plants.

**Key words:** Thermal power plant, modernization, megatrends, BAT, environment, emission, renewable, energy efficiency, EU

# CO-FIRING AND BIOMASS CONVERSION EXPERIENCES IN EUROPE AND THE WORLD

**Emmanouil Karampinis [1,2*], Panagiotis Grammelis [1], Emmanuel Kakaras [1,2]**

[1] Centre for Research and Technology Hellas/Chemical Process and Energy Resources Institute, Egialias 52, 15125 Marousi, Athens, Greece

[2] National Technical University of Athens / Laboratory of Steam Boilers and Thermal Plants, 9 Heroon Polytechniou, 15780 Zografou, Athens, Greece

[*]karampinis@certh.gr

Co-firing can be defined as the simultaneous combustion of two or more fuels in the same plant in order to produce one or more energy carriers, [1]. The most common application of co-firing is the partial substitution of coal in large-scale utility power plants by solid biomass fuels or waste. Generally, biomass co-firing is considered as one of the most cost efficient and easily deployed ways for mitigating the $CO_2$ emissions from the coal power sector. However, adopting co-firing solutions may have an impact on different operational aspects of a coal power plant and creates new challenges as regards biomass sourcing. Implementation is also heavily affected by the policy framework.

The purpose of the present work is to present an overview of co-firing experiences in Europe and other parts of the world. There are different drivers for using biomass / waste co-firing in a coal power plant. The oldest – and still is use – is the utilization of "opportunity" fuels, which may have fuel prices lower than coal or even negative (if a gate-fee is applied); however, the availability and price of such fuels may be subject to seasonal variations. Rising $CO_2$ prices is also a driver in European markets, since biomass is considered as carbon neutral by the European Emissions Trading Scheme (ETS). The support schemes established in several European (United Kingdom, Netherlands, Poland) or Asian (Japan, South Korea) countries have resulted in more stable conditions for the adoption of biomass co-firing by utilities [2].

There are different technical options for implementing co-firing, see Figure 1, [3]. Direct co-firing implies that biomass and coal are combusted in the same furnace, using same or different mills and burners as appropriate. It is easy to adopt and low cost solution. There are numerous industrial references to its application, but this option usually limits the biomass share to no more than 20 % on thermal basis and implies continued use of coal. Indirect or gasification co-firing requires the installation of a new biomass gasifier, the syngas of which is combusted in the coal furnace. Although this option allows for the utilization of more "difficult" biomass fractions and with higher thermal substitution shares, it comes with a higher CAPEX due to the need for a new gasifier. Parallel co-firing is the installation of a new, dedicated biomass boiler, connected with coal plant on the steam / water cycle. Like indirect cofiring, it gives more flexibility and provides improved conditions for biomass use, but also comes with a higher CAPEX.

Two new approaches to using biomass in coal-fired power plants are also outlined. In biomass repowering, the fuel switch from coal to biomass, in most cases wood pellets, is almost complete. Several such conversion projects have already been implemented in units such as Rodenhuize 4 (Belgium), Drax 1 – 4 (United Kingdom), Avedøre 1 (Denmark) and Yeongdong 1 (South Korea). Another alternative is the use of thermally treated biomass. Thermal treatment can mean different technologies (e.g. steam explosion, torrefaction, hydrothermal carbonization) aiming to change the biomass fuel properties into something more closely resembling coal, thus allowing its easier storage, transportation and milling. The use of thermally treated biomass in co-firing applications has been demonstrated in large-scale trials and in one commercial retrofitting cases in Thunder Bay Unit 3 in Canada.

Finally, the perspectives of the use of co-firing and repowering in Bosnia and Herzegovina are briefly discussed, as concerns the case studies for Elektroprivreda BiH implemented within the BIOFIT Horizon 2020 project (www.biofit-h2020.eu). The studies concern the possibility of implementing direct co-firing at Unit 6 of the Tuzla power plant using various local biomass sources (sawdust, agricultural residues, energy crops) up to 30 % of the mass input and the full biomass repowering of Unit 5 of the Kakanj power plant.

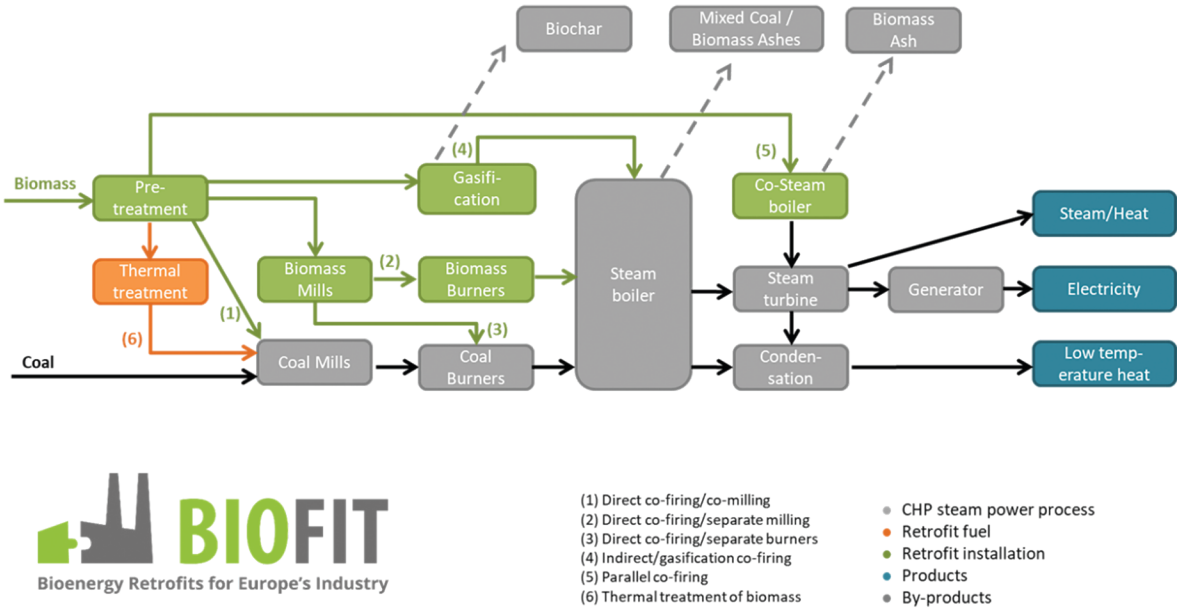



**Figure 1**: Overview of technical options for biomass co-firing / conversions in coal plants [3]

**Key words:** Biomass co-firing; biomass conversion; coal; repowering.

## References

[1] J. Hansson, G. Berndesa, F. Johnsson, J. Kjärstad: "Co-firing biomass with coal for electricity generation—An assessment of the potential in EU27", Energy Policy, volume 37, issue 4, pp. 1444-1455, April, 2009.

[2] X. Zhang: "Support mechanisms for cofiring biomass with coal", IEA Clean Coal Centre, pp. 1-60, June, 2019.

[3] D. Rutz, R. Janssen, P. Reumerman, J. Spekreijse, D. Matschegg, D. Bacovsky, A. Gröngröft, S. Hauschild, N. Dögnitz, E. Karampinis, D.S. Kourkoumpas, P.Grammelis, K. Melin, H. Saastamoinen, A.I.S. Torres, R. Iglesias, M. Ballesteros, G. Gustavsson, D. Johansson, A. Kazagić, A. Merzić, D. Trešnjo, H. Dagevos, S.J. Sijtsema, M.J Reinders, M. Meeusen: "Technical options for retrofitting industries with bioenergy – A handbook", WIP Renewable Energies, Munich, Germany, pp. 55-68, 2020.

# PRODUŽENJE ŽIVOTNOG VIJEKA TERMOELEKTRANA - REVITALIZACIJA, POVEĆANJE SNAGE I POBOLJŠANJE EFIKASNOSTI

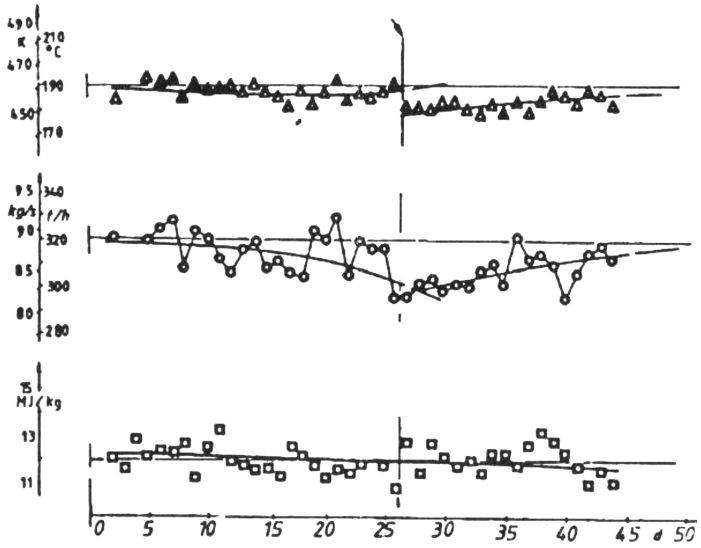
**Nijaz Delalić [1], Zdravko Milovanović [2*], Dušan Golubović [3], Izet Smajević [4]**

[1] Univerzitet u Sarajevu, Mašinski fakultet, Katedra za energetiku, Vilsonovo šetalište 9, 71000 Sarajevo, BiH
[2] Univerzitet u Banjoj Luci, Mašinski fakultet Banja Luka, Katedra za hidro i termoenergetiku, Stepe Stepanovića 71, 78000 Banja Luka, BiH
[3] Univerzitet u Istočnom Sarajevu, Mašinski Fakultet Istočno Sarajevo, Katedra za termoenergetiku i procesno mašinstvo, Vuka Karadžića 30, 71123 Istočno Novo Sarajevo, BiH
[4] Akademija nauka i umjetnosti Bosne i Hercegovine, Odjeljenje tehničkih nauka, Odbor za energiju, energetiku i okoliš, Bistrik 7, 71000 Sarajevo, BiH
[*] zdravko.milovanovic@mf.unibl.org

Smanjenje pouzdanosti i sigurnosti pogona, i prateće pogoršanje radnih karakteristika termoelektrana s vremenom njihove eksploatacije je u prvom redu posljedica pada čvrstoće materijala (iscrpljivanje životnog vijeka), što nakon određenog vremena zahtijeva trajnu obustavu termoelektrane, ili najradikalniji korak u procesu reinženjeringa – realizaciju procesa revitalizacije, uz obavezne prateće procese sanacije, rekonstrukcije i modernizacije postrojenja [1]. U ovom drugom slučaju, ako do njega dođe, se zahtjeva i ispunjenje dodatnog uslova, a to je ekonomska opravdanost modernizacije date termoelektrane u odnosu na izgradnju adekvatnog novog elektroenergetskog objekta. Polazeći od rezultata analize pouzdanosti i sveukupne održivosti određene termoelektrane, kao i moguće pojave otežavajućih faktora u zavisnosti od vrste, kapaciteta, opšteg stanja objekta, načina njegove prethodne eksploatacije i održavanja, te specifičnih makro i mikro uslova lokacije i očekivanih promjena tržišnih uslova u produženom periodu rada, može se pretpostaviti da sa aspekta investicionog poduhvata revitalizacija nekih termoelektrana ima još uvijek ravnopravan status sa izgradnjom novih postrojenja. Za pouzdanu ocjenu ekonomske i okolinske održivosti revitalizacije i modernizacije termoelektrane je potrebno unaprijed jasno i precizno definirati ciljeve i sadržaj tog zahvata. Uz dovođenje parametara termoelektrane, koji su tokom prethodne eksploatacije pogoršani, na projektovani, ili na još bolji nivo, revitalizaciji se dodaju i procesi sanacije, rekonstrukcije, modernizacije ili čak kompletne zamjene termoelektrane novom. U posljednjem slučaju se radi o zamjenskim, prioritetno energetski visokoefikasnim ko(tri)generativnim termoelektranama. Cilj ovakve revitalizacije termoelektrana je da se u BiH otvori mogućnost održive tranzicije elektro-energetskog sektora, koja će u maksimalno mogućoj mjeri biti usaglašena sa planovima i direktivama EU u toj oblasti, kao i sa dokumentima EZJIE. Značajna podrška uspješnom pogonu, a naročito izradi plana i dokumentacije za uspješnu revitalizaciju/modernizaciju određene termoelektrane su periodična i specijalistička mjerenja usmjerena na ocjenu kvaliteta tehnološkog procesa (po dijelovima ili u cjelini), kao i pojedinih komponenti cjelokupnog bloka [2]. Posebno značajni rezultati u tom smislu se mogu postići primjenom metoda kompjuterske simulacije industrijskih procesa [3].

Termoelektrane u Bosni i Hercegovini su oslonjene isključivo na domaće mrke ugljeve i lignite. To su uglavnom slaboreaktivni ugljevi, u manjoj ili većoj mjeri - pa čak do izrazito skloni prljanju kotlovskih ogrijevnih površina, a njihov sastav varira od rudnika do rudnika, pa u ekstremnim slučajevima i od kopa do kopa u okviru istog rudnika. Iz tih razloga je otežano projektovanje sistema za sagorijevanje takvih ugljeva, kao i organizacija i kontrola procesa sagorijevanja u postojećim termoelektranama. Ovo je jedan od glavnih razloga što postojeće termoelektrane u Bosni i Hercegovini nemaju zavidnu energetsku i vremensku raspoloživost. Naslage šljake i pepela se formiraju na ogrijevnim površinama koje su smještene u širokom dijapazonu temperatura dimnih plinova - od (topione) komore za sagorijevanje pa sve do zagrijača vazduha. Iz toga je nužno proistekla potreba za razvojem domaćih inovativnih teh-

nologija u svrhu prevazilaženja navedenih (i drugih), u određenoj mjeri specifičnih domaćih, poteškoća u pogonu postojećih termoelektrana. Neke od tih tehnologija, koje su rezultat vlastitih istraživanja u laboratoriji i realnom pogonu, su se u kasnijoj dugogodišnjoj svakodnevnoj primjeni u praksi dokazale kao pouzdane i veoma efikasne. Dobar primjer za to je Impulsno detonacioni postupak čišćenja vanjske strane ogrijevnih površina u pogonu kotla [4], Slika 1. Za ovaj postupak, koji je patentiran, je iskazan veoma rasprostranjen interes i izvan Bosne i Hercegovine. Njegovo uključivanje u tehnološko rješenje budućih zamjenskih termoelektrana će dodatno doprinijeti njihovoj energetskoj i vremenskoj raspoloživosti, energetskoj efikasnosti, ekonomičnosti pogona i učinit će ih okolinski još prihvatljivijim.




**Slika 1:** Efekat Impulsno detonacionog postupka čišćenja u pogonu kotla, TE Kakanj, Blok 5, 360 MWt

Gore: temperatura dimnih plinova na kraju kotla (°C); Sredina: proizvodnja pare (t/h), sve tokom 45 dana neprekidnog pogona, najprije (0-25 dana) bez, a zatim (26-45 dana) sa primjenom impulsno detonacionog postupka čišćenja (ovdje konvektivnih) ogrijevnih površina kotla. Dolje: prosječna toplotna moć uglja (kJ/kg) – praktično ista.

**Ključne riječi:** energetska tranzicija, inovativne tehnologije, računarska simulacija/mjerenje, revitaliacija/modernizacija, termoelektrane

## Literatura

[1] Z.N. Milovanović et al., 2019, Planning Methods for Production Systems Development in the Energy Sector and Energy Efficiency, Chapter 3 in the book Advances in Reliability Analysis and its Applications, Editors Mangey Ram and Hoang Pham, Springer Int. Publ.: 95-148

[2] N. Delalić i dr., Normativno ispitivanje bloka 5, snage 110 MW u Termoelektrani "Kakanj", Mašinski fakultet Sarajevo, 2003.

[3] A. Đugum, K. Hanjalić, 2019, Numerical simulation of coal-air mixture flow in a real double-swirl burner and implications on combustion anomalies in a utility boiler, Energy 170: 942-953

[4] I. Smajević, K. Hanjalić, 2004, Zwanzig Jahre erfolgreiche Anwendung der Stosswelen-Reinigungstechnik in einem mit Kohle befeurtem Kraftwerk, VGB PowerTech 8: 71-75

# SJEDNICA IV / SESSION IV

## Budućnost novih TE u održivoj tranziciji do 2050.
## Perspectives of new TPPs in a sustainable transition until 2050

# IS THE TWILIGHT OF COAL FOR THE BENEFIT OF ALL?

**Miodrag Mesarović**

Serbian WEC Member Committ
Energoprojekt Entel, Belgrade, Serbia
mmesrovic@ep-entel.com

The current energy transition is viewed by many as unprecedented in the human history. Unlike all former spontaneous transitions, this one is carried on under a series of geopolitical, economic and environmental pressures, with the climate change mitigation as its principal driver. Based dominantly on fossil fuels, the global energy sector is the major source of anthropogenic emissions and therefore is forced to switch from fossil to carbon-free energy sources. Such transition towards a low carbon economy implies significant technological, economic and social challenges, both due to market-driven trends and climate policies. The transition away from fossil fuels could leave a lot of them underground, and thus hurt national economies of many countries, particularly of those undeveloped that would thus be prevented to develop by the use of fossil resources as historically did developed counties and consequently disturbed the atmospheric concentration of CO2. Particularly sensitive are the economies of countries that rely mainly on electricity generated from coal. Under the current energy and climate policy of the EU, the coal-intensive regions have to prepare for a costly phasing-out of coal mining and to adjust their power generation infrastructure to the available renewable energy sources. The Western Balkan countries could be prevented to benefit from their unexpensive coal resources for power generation, and risk the raise of generation cost by the introduction of a carbon tax under the Energy Community Treaty with the EU.

The motto of the World Energy Council ("Sustainable energy supply for the greatest benefit of all", [1]) becomes questionable in case of the current efforts to prevent climate change by cutting anthropogenic emissions of $CO_2$ to the atmosphere. To achieve this common goal, the rich countries, which are responsible for most of the $CO_2$ emissions while increasing their wealth, may benefit again from selling technology to cut emissions by the poor countries. Cumulative anthropogenic emissions of $CO_2$ since 1751 reached over 1500 billion tonnes, [2]. The largest share of that quantity came from the US (25%), the EU-28 (22%), China (13%), Russia (6%) and Japan (4%), [3]. The poorest countries, which have contributed less than 1% of the global emissions, are the most vulnerable to the expected climate change impacts, [3]. The annual emissions of $CO_2$ increased from 2 billion tonnes in late 1800s to over 36 billion tonnes today and continue to raise. Currently, China is the world's largest $CO_2$ emitter (about 25% of total emissions), followed by the USA (15%), EU-28 (10%), India (7%); and Russia (5%), [3]. However, China and many developing countries have very low per capita $CO_2$ emissions compared to developed countries. Consequently, quite large inequalities (more than 100-fold) between countries in $CO_2$ emissions call for a fair distribution of responsibilities to cut them.

Since the global average surface temperature already raised by more than 1°C above its pre-industrial level and the atmospheric concentrations of $CO_2$ increased above 400 ppm, the need for a collective action to limit their further increases is very urgent. But, immediate collective action to prevent climate change beyond repair is still missing. Yet, there is a hesitation, and even strong denials by some countries of the anthropogenic causes of climate change, partly based on still existing scientific uncertainties that feed such a scepticism, [4].

*Common goal, but different paths*: According to the Paris Agreement reached in December 2015, all countries are obliged to cut their anthropogenic emissions so that the total emissions reach net zero values between 2055 and 2070 and continue on as net negative emissions in

order to limit global temperature raise in 2100 to ≤ 2°C above its preindustrial level. However, the efforts of the UN bodies so far failed to make the Paris Agreement fully operational, and the anthropogenic emissions of greenhouse gases continue to raise. Thus, the world today is not on track to meet its agreed target. Instead, under current policies of some major emitters of $CO_2$, the expected global temperature raise by the year 2100 will be 3.1°C - 3.7°C above pre-industrial level, [3]. This is considered to be a serious stress for many species and to put humans under a severe threat. To reverse emission trends, a huge pressure must be put on all countries to stop their current use of fossil fuels, particularly of coal for generating electricity. This pressure will primarily hit most of the undeveloped countries, which will thus be prevented to benefit from the use of their own resources for development as historically did the developed countries. Coal is currently the most abundant fossil fuel in Europe, particularly in Western Balkans, but faces a total twilight over next decades. The European Energy platform provides that the countries may follow different paths when meeting the common climate objectives, [5]. Nevertheless, the EU Coal Regions in Transition platform supports the coal-intensive regions in Europe to use the common best practices to facilitate their transition towards non-carbon energy. In that respect, the EU is financing a Horizon 2020 project for nine European coalintensive regions, of which two in the countries (Ukraine and Serbia) outside the EU-28, [6]

*Concluding remark*: Urgent cuts of anthropogenic $CO_2$ emissions is needed to save the living conditions for all. Unlike developing countries, developed countries have historically benefited from the use of fossil fuels for development, and will benefit again from technology transfer to cut emissions.

**Key words:** Climate change, Coal, Energy transition, European Union, Thermal power plants

## References

[1] https://www.worldenergy.org/
[12] Sterner, T., 2015, “Higher costs of climate change”, Nature (2015), 527, pp. 177–178
[13] Ritchie, H. & Roser, M., 2017, “$CO_2$ and Greenhouse Gas Emissions”, Carbon Brief, May 2017, Available at https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions/
[14] Mesarović, M., 2015,” Scientific Uncertainties Feed Scepticism on Climate Change”, Thermal Science, Vol. 19 (2015), Suppl. 2, pp. S259-S278
[15] *** “Energy Transition in Europe-Common Goals, but Different Paths”, EuroCASE, Paris, France, 2019, pp. 1-35, http://www.euro-case.org/platforms/platform-energy/
[16] www.tracer-h2020.eu

# BUDUĆNOST NOVIH TERMOELEKTRANA U BIH OSLONJENIH NA KOGENERACIJU, INTEGRACIJU BIOGORIVA I OPTIMIZACIJU PROCESA

**Anes Kazagić[1*], Petar Gvero[2], Miladin Trbić[3], Izet Smajević[4]**

[1] JP Elektroprivreda BiH d.d.-Sarajevo, Vilsonovo šetalište 15, Sarajevo, BiH
[2] Univerzitet u Banjoj Luci, Mašinski fakultet Banja Luka, Stepe Stepanovića 71, 78000 Banja Luka, BiH
[3] EFT Group, TE Stanari, Stanari, BiH
[4] Akademija nauka i umjetnosti Bosne i Hercegovine, Odjeljenje tehničkih nauka, Odbor za energiju, energetiku i okoliš, Bistrik 7, 71000 Sarajevo, BiH
[*] a.kazagic@epbih.ba

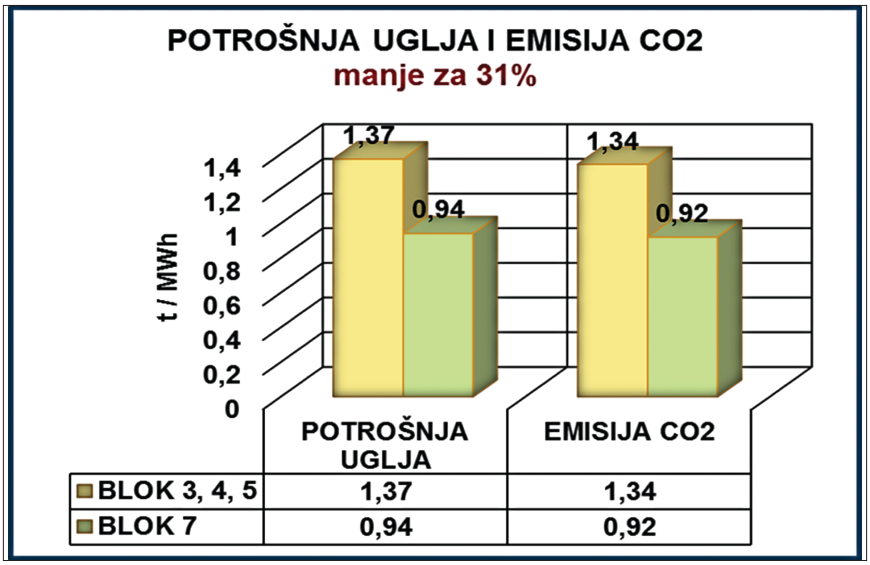
Izazovi i zahtjevi dekarbonizacije elektroenergetskog sektora s jedne strane, te imperativ konkurentnosti na tržištu s druge strane, često su kontradiktorni zahtjevi za elektroprivredne kompanije u Evropi, pa tako i za one koje djeluju u Bosni i Hercegovini. Pri tome, proizvođači energije traže načine kako da pomire pomenute zahtjeve, te iznađu svoje sopstvene pravce razvoja, ovisno o specifičnim okolnostima i okruženju u kojem djeluju, što se prije svega odnosi na raspoložive resurse, regulativu, obaveze preuzete međunarodnim ugovorima, politike cijena i drugo.

U radu se prezentuje status energetske tranzicije u svijetu i Evropi, s akcentom na planove do 2035. i 2050. god. Postoje mnogi izazovi u ovom procesu, kako bi se realno mogli dostići carbon-free ciljevi u 2050. god. Dalje se analizira proizvodni portfolio elektroenergetskog sistema u BiH, koji je trenutno dominantno, cca 60%, zasnovan na uglju. Identificirani su izazovi i ograničenja, ali i benefiti i pozitivna opredjeljenja na putu tranzicije ka EES BiH koji će dominantno biti zasnovan na obnovljivim izvorima.

U tom kontekstu predočena je modernizacija termoelektrana u BiH, tj. termoelektrana u okviru JP Elektroprivreda BiH (TE Tuzla, TE Kakanj), zatim Elektroprivrede RS (TE Gacko, TE Ugljevik) te novoizgrađene termoelektrane Stanari, kao i plan za nastavak ovog procesa. Predočavaju se efekti do sada urađenih unapređenja postojećeg parka termoblokova u BiH kroz proces rekonstrukcija/modernizacija, kao i planirane dalje mjere na povećanju energetske efikasnosti, smanjenju emisije $CO_2$ i redukciji emisija polutanata, kroz dalju modernizaciju postojećeg parka termoelektrana, odnosno planirane zamjenske termoblokove. Poseban osvrt se daje na mogućnost proširenja kogeneracije termoblokova kao i imperativ unapređenja postojećih i izgradnju novih sistema daljinskog grijanja, uz primjenu i podršku realizacije projekata integracije obnovljivih izvora energije u sistemima daljinskog grijanja. Rad se fokusira i na moguću primjenu tehnologija biomase u termoelektranama, u opciji djelimične ili potpune konverzije na biomasu (co-firing tehnologija), na demonstracijskim primjerima termoblokova JP Elektroprivreda BiH.

U daljim razmatranjima se može podcrtati da su elektroprivredne kompanije u BiH koje u svom portfoliju posjeduju termoelektrane, opredjeljene uravnoteženom i održivom razvoju baziranom na intenziviranju gradnje elektrana na obnovljive izvore energije s jedne strane (hidro, vjetar, solar i dr.), te unapređenju tehnologija proizvodnje u postojećim termoelektranama s druge strane. To su procesi koji se moraju odvijati paralelno, pri čemu oba vode ka jedinstvenom setu ciljeva: povećanju udjela čiste obnovljive energije, smanjenju emisije $CO_2$ i emisije polutanata, povećanju energetske efikasnosti i smanjenju proizvodnih troškova. Bitno je istaći da se u radu potencira modernizacija postojećih ili gradnja zamjenskih blokova jer se tim mjerama značajno smanjuje postojeća emisija $CO_2$ te se time doprinosi ispunjenju afirmativnog nacionalnog klimatskog plana, Slika 1. Nasuprot tome, planovi gradnje novih TE

na nekim novim lokacijama, prinosili bi nove emisije $CO_2$ u odnosu na postojeće stanje, a što nije u skladu sa afirmativnim ciljevima nacionalnog klimatskog plana.




**Slika 1**. Smanjenje potrošnje uglja i emisije CO2 kroz modernizaciju TE Tuzla zamjenskim blokom 7 je 31%

U zaključku rada se, po osnovu iznijete argumentacije, potencira da unapređenje postojećih termoelektrana, kroz modernizaciju i nadogradnju postojećih termoblokova - ili izgradnju zamjenskih jedinica usklađenih sa IED i visoke neto efikasnosti, s visokoefikasnom kogeneracijom, s nadogradnjom biogorivima, te proširenim dijapazonom i fleksibilnošću variranja opterećenja, mogu realno naći svoje mjesto u tranzicijskom elektroenergetskom sistemu BiH, te ga i dodatno unaprijediti.

**Ključne riječi:** energetska tranzicija, termoelektrana, zamjenski termoblok, ugalj, biomasa, kogeneracija, retrofit, modernizacija

## Literatura

[1] NERP BiH, MVTEO BiH, decembar 2015.
[2] Okvirne dugoročne projekcije Elektroprivrede BiH do 2035. godine, juli 2019.
[3] Podaci TE Stanari, EFT Group, oktobar 2019.
[4] BIOFIT Horizon 2020 project, European Commission, https://www.biofit-h2020.eu/

# RUDARSTVO BIH U ENERGETSKOJ TRANZICIJI

**Edin Lapandić[1], Omer Jukić[2], Dimšo Milošević[3], Boško Vuković[4]**

[1]JP Elektroprivreda BiH, Sektor za strateški razvoj, Vilsonovo šetalište 15, Sarajevo, BiH
[2]ANUBiH/OTN, Odbor za energiju, energetiku i okoliš, Bistrik 7, Sarajevo, BiH
[3]MH „Elektroprivreda RS"- MP A. D. Trebinje ZP „R i TE Ugljevik" A. D. Ugljevik, BiH
[4]MH „Elektroprivreda RS"- MP A. D. Trebinje ZP „R i TE Gacko" A. D. Gacko, BiH
e.lapandic@epbih.ba

Ugalj je najrasprostranjenije fosilno gorivo i predstavlja glavni energent za proizvodnju električne energije u svijetu. Udio uglja u proizvodnji električne energije na svjetskom nivou je 38%, a u Evropi 21,6%. Osim toga, ključna je komponenta u proizvodnji čelika i betona, podržava poslovanje i industrije, utiče na ekonomski rast te osigurava masovno zapošljavanje što je od velikog značaja posebno u najmnogoljudnijim regijama svijeta. Danas se ovaj energent nalazi pred ozbiljnim optužbama (zbog emisija CO2) da utiče na klimatske promjene, zbog čega međunarodne institucije uporno pozivaju na redukciju potrošnje uglja, ali u tom pogledu nije se puno postiglo. Od početka trećeg milenija proizvodnja uglja je u velikom porastu, i tek je u posljednjih 5 godine nešto opala. Razlog je vrlo jednostavan; ugalj u sistemu proizvodnje električne energije obezbjeđuje sigurnost i pouzdano snabdijevanje i još uvijek je najjeftiniji energent.

Prema najnovijim istraživanjima koja su objavljena u UN, 2050. godine na zemlji će živjeti 9,7 milijardi stanovnika, što je za 2 milijarde više u odnosu na trenutnih 7,7 milijardi, zbog čega će i potrebe za električnom energijom znatno porasti. Uvažavajući činjenicu da obnovljivi izvori ni fizički ni prostorno, ne mogu preći 20% do 2050. godine bez obzira na politike subvencioniranja, ugalj će ostati jedan od osnovnih izvora energije. Pitanje je samo kako ćemo ugalj koristiti za proizvodnju energije, a ne i da li ćemo to raditi. Dakle, uloga jednog od glavnih snabdjevača (energenta za proizvodnju električne energije) će i u budućim decenijama ostati na uglju ali maksimalo još stotinjak godina (u EU do 2050). Naime, potvrđene rezerve fosilnih goriva sa današnjim stepenom eksploatacije bit će iscrpljene u narednim desetljećima (plin za 51, nafta za 50 i ugalj za 132 godine). Ovo treba uzeti sa rezervom jer se istraživanja konstatno vrše i otkrivaju se nova i nova nalazišta fosilnih goriva. No i pored toga, kad tad, fosilna goriva će se iscrpiti ili će se odustati od njih ali ostaje pitanje na koje današnja civilizacija ne zna odgovor: Koja je namjena uglja, nafte i plina? „Jesmo li generacija koja će za 200 godina potpuno spaliti ove resurse/bogatstva čiju svrhu ćemo otkriti (možda) tek u „nekoj" budućnosti"?

Uvažavajući sve navedeno, ali i činjenicu da energija pokreće današnju civilizaciju, proces tranzicije mora biti postupan i realno planiran, pošto u ovom trenutku nauka i tehnološki razvoj nemaju alternativno rješenje. Doda li se tome veliki iskorak i napredak tehnologija podzemnog gasificiranja uglja koje se smatraju čistim, dodatno se ojačava pozicija uglja. Sve navodi, da će se morati sačekati da tehnologije skladištenja energije dožive visok stepen tehnološkog razvoja, što bi napravilo prevrat i obnovljivim izvorima omogućilo potpuno novu poziciju u sistemu proizvodnje energije.

Kada je u pitanju EU, ugalj (uključujući kameni ugalj i lignit) - trenutno se iskopava u 12 zemalja EU, u ukupno 41 regionu. To ga čini najobimnijim fosilnim gorivom u EU i važnim izvorom ekonomske aktivnosti u ovim regionima. Sektor proizvodnje električne energije iz uglja osigurava radna mjesta za oko 240.000 ljudi: oko 180.000 u rudarstvu i oko 60.000 u termoelektranama na ugalj. Ugalj čini petinu ukupne proizvodnje električne energije u EU i važan je izvor goriva za industrijske procese, kao što je proizvodnja čelika.

Evropa je krenula u energetsku tranziciju, a kao odgovor EU stvara energetsku uniju zasnovanu na obnovljivim izvorima energije, inovacijama i digitalizaciji. Međutim, primjetno

je, da ponašanje velikih proizvođača i potrošača uglja ne prati planiranu dinamiku smanjenja eksploatacije fosilnih goriva, zbog čega se rokovi prolongiraju. Njemačka i Poljska zajedno čine 57% ukupne potrošnje uglja u EU, tako da bi smanjenje upotrebe uglja na tim tržištima imalo značajan utjecaj na ukupnu upotrebu uglja u EU.

Kada je u pitanju Bosna i Hercegovina, radi se o zemlji koja ima veliki potencijal u uglju i hidroenergiji. U pogledu proizvodnje električne energije, trenutni stepen iskoristivosti ovih resursa je 60:40% u korist uglja. Ukupno je u radu pet termoelektrana na ugalj sa deset blokova koji su u funkciji (četiri u Tuzli, tri u Kaknju, i po jedan u Ugljeviku, Gacku i Stanarima), ukupne instalirane snage od 2.065 MW. Svi blokovi (izuzev termoelektarne u Stanarima) izgrađeni su prije 1990-te, a neki od njih da bi električnom energijom snabdijevali druge republike ex Jugoslavije.

Ukupne geološke rezerve uglja u BiH iznose 5,65 milijardi tona (ligniti 3,24 i mrki ugljevi 2,41 mil. tona) i temeljni je resurs izrade strateških dokumenata entiteta BiH. Prema ovim dokumentima, domaći ugalj će ostati glavni izvor proizvodnje električne energije čak i u scenariju intenzivne gradnje kapaciteta na bazi obnovljivih resursa.

U rudnicima uglja u BiH posljednjih nekoliko decenija nije bilo investiranja u nabavku opreme za unapređenje tehnologije dobivanja „čistog“ uglja (bitan uslov za redukciju $SO_2$, $NO_x$ i prašine pri sagorijevanju ovih ugljeva u kotlovima termoelektrana) kako bi se dobio ugalj optimalnog kvaliteta i zaštitio okoliš. Rezerve kvalitetnog uglja su, uglavnom, otkopane, pa je poboljšanje kvaliteta uglja koji se trenutno otkopava, zbog niza razloga, neminovnost. Kvalitet uglja koji se danas otkopava u rudnicima BiH zadovoljava uslove za sagorijevanje u fluidiziranim kotlovima (CFB tehnologija-sagorijevanje uglja uz visoku efikasnost sagorijevanja) koji ispunjavaju sve limite emisija propisanih ekološkim standardima EU, niske emisije $SO_2$ i niske emisije $NO_x$.

**Ključne riječi:** čišćenje uglja, fluidni kotlovi, rudarstvo, tranzicija

## Literatura

[1] ANG, B. W.; SU, Bin. „Carbon emission intensity in electricity production: A global analysis“. Energy Policy, 2016, 94: 56-63.

[2] CLERICI, Alessandro; ALIMONTI, G. World energy resources. In: EPJ Web of Conferences.

[3] HEIDRICH, Craig; FEUERBORN, Hans-Joachim; WEIR, Anne. Coal combustion products: a global perspective. In: World of Coal Ash Conference. 2013. p. 22-25. EDP Sciences, 2015. p. 01001.

[4] O. Jukić: Rudarstvo – skriveni potencijal privrede BiH, ANUBiH/OTN-OEEO Posebna izdanja, knjiga CLXX, Sarajevo 2017.

# 3. ZAKLJUČCI / CONCLUSIONS

Globalna dekarbonizacija kao preduslov ublažavanja klimatskih promjena, i u vezi s tim predviđena tranzicija energetskog sektora ka obnovljivim izvorima, je jedan od najvećih globalnih izazova 21. stoljeća. Posebno je zahtjevna energetska tranzicija zemalja u razvoju koje su u velikoj mjeri oslonjene na ugalj, kao što su Bosna i Hercegovina (BiH) i neke druge zemlje Zapadnog Balkana, ali i neke zemlje EU.

U organizaciji Akademije nauka i umjetnosti Bosne i Hercegovine (ANUBiH) i suorganizaciji JP Elektroprivreda BiH d.d. - Sarajevo kao pokroviteljem, dana 21. 11. 2019. u prostorijama ANUBiH održano je Savjetovanje pod naslovom "*Budućnost postojećih i novih termoelektrana u Bosni i Hercegovini u energetskoj tranziciji*". Savjetovanje je motivirano potrebom da nauka i struka u BiH iznesu svoj stav o ulozi postojećih i zamjenskih termoelektrana u održivoj tranziciji BiH ka dekarboniziranom društvu do 2050. godine – što je cilj postavljen u EU. Pri tome, BiH nauka i struka želi poslati jasnu poruku prvenstveno Energetskoj zajednici, ali i svima drugima, da je opredijeljena pratiti i ispoštovati postavljene ciljeve, uvažavajući potrebu svake države pojedinačno, za vlastitom energetskom održivošću tokom i nakon tranzicije. U tom pogledu je za BiH potrebno definirati jasnu viziju, sa prohodnim putem do postavljenog cilja, uzimajući u obzir sve relevantne direktive EU, ali i realne mogućnosti i potrebe BiH na tom putu.

Rezultati Savjetovanja, na kojemu su aktivno učestvovali istaknuti naučnici i stručnjaci pozvani kao predavači iz zemalja EU i Zapadnog Balkana, a čija se energetika značajno oslanja na ugalj: Njemačka, Poljska, Grčka, Srbija, Sjeverna Makedonija i BiH, uključujući i predstavnika Sekretarijata Energetske zajednice, su tokom Savjetovanja i završne diskusije pretočeni u Zaključke. Zaključci Savjetovanja daju se u nastavku, sa ciljem da zajedno sa izloženim prezentacijama, posluže nadležnim institucijama u BiH kao važan ulazni dokumenti za izradu Nacionalnog plana energetske tranzicije BiH do 2050. godine. Taj Plan treba uraditi u što je moguće kraćem roku.

Zaključci:

1. Globalna dekarbonizacija, kao preduslov ublažavanja klimatskih promjena, i u vezi s tim predviđena tranzicija energetskog sektora ka obnovljivim izvorima energije, treba biti socijalno i ekonomski održiva, i kao takva je izazov 21. vijeka.
2. Posebno je izazovna energetska tranzicija zemalja u razvoju koje su dominantno oslonjene na ugalj, među kojima je i Bosna i Hercegovina.
3. Zemlje EU i regiona koje su oslonjene na ugalj, Njemačka, Poljska, Grčka, Srbija, Sjeverna Makedonija, provode svoje vlastite programe energetske tranzicije:
   **Njemačka** planira potisnuti ugalj do 2038. god. Ta godina još nije odobrena u Njemačkom Bundestagu, zbog zahtjeva za obezbjeđenje sredstava potrebnih za saniranje TE/ugljenog sektora u tranzicijskom periodu koja se mjere u milijardama EUR-a. Ipak, postoje ozbiljne intencije da se ugalj potisne čak i ranije. Paralelno raste udio OIE (uglavnom vjetar i solar), koji u kumulativu pokriva povećanje potražnje za energijom. Doprinos TE na ugalj u novom EES Njemačke baziranom na OIE, prelazi iz bazne proizvodne jedinice u proizvodni objekat sa ulogom učešća u pokrivanju varijacija izlazne snage velikog udjela OIE, prvenstveno vjetroelektrana i fotonaponskih elektrana. U jednom takvom sistemu važno je osigurati visoku fleksibilnost, a to znači skratiti vrijeme starta i promjene opterećenja TE na ugalj – na što se trenutno stavlja fokus u modernizaciji TE na ugalj u ovoj zemlji. Po pitanju energetike u Njemackoj je istaknut aktivan angažman stručnjaka u pronalasku adekvatnog rješenja posljedice gašenja kogenerativnih termoblokova koji i toplinskom energijom snabdijevaju okolna mjesta.

**Poljska** i danas dominantno električnu energiju dobija iz svojih TE na ugalj, blizu 80%. U zadnje vrijeme intenzivirana je izgradnja vjetroelektrana čiji udio u proizvodnji zadnjih godina raste, s projekcijom daljeg rasta u narednom periodu. Jedan dobar dio termoblokova na ugalj u Poljskoj snabdijeva se biomasom kao sekundarnim gorivom, uobičajeno do 20% udjela biomase sa ugljem. Na ovaj način poboljšava se karbonski „footprint" Poljske proizvdonje iz TE na ugalj.

**Grčka** posjeduje značajne rezerve niskovrijednog lignita koje se trenutno koriste dominantno u TE na ugalj u sjeverozapadnoj Grčkoj regiji zapadna Makedonia, gdje nacionalna Grčka elektroprivreda trenutno gradi i novi lignitni termoblok na ugalj Ptolemaida snage 650 MWe. Blok je u poodmakloj fazi izgradnje (blizu 70% radova je već završeno, izvođač je Micubiši-Hitači), i planiran je da bude pušten u pogon do 2023. god. U Grčkoj se trenutno vode velike polemike u vezi nedavne objave grčkog Ministra energetike da će ova zemlja potisnuti ugalj 2028. god, obzirom da je novi lignitni blok u završnoj fazi izgradnje.

**Srbija** namjerava održati dugoročno u pogonu svoje termoblokvoe na ugalj u TE Nikola Tesla i TE Kostolac. U revitalizaciju tih blokova se ulažu značajna sredstva i napori, te se grade postrojenja odsumporavanja za termoblokove koji ostaju u pogonu. Međutim paralelno se u Srbiji odnedavno grade vjetroparkovi veće snage na više lokacija, s ciljem povećanja udjela energije iz iz OIE. Srbija dodatno u proizvodnom portfoliu planira i prirodni gas, u postrojenjima koja će proizvoditi električnu i toplinsku energiju (CCGT postrojenja).

**Sjeverna Makedonija** posjeduje samo jednu TE na ugalj, TE Bitola, koju planira ugasiti najdalje 2040 god. Nedostajuću proizvodnju nadomjestiće iz prirodnog gasa i OIE, shodno nacionalnoj energetskoj strategiji do 2040. god.

4. Bosna i Hercegovina raspolaže značajnim potencijalom za izgradnju energetskih kapaciteta na OIE, posebno hidroelektrana, i treba se usmjeriti na praktičan angažman tih resursa, za šta su potrebni stanovito vrijeme i finansijska sredstva. Sve tri nacionalne elektroprivredne kompanije su poduzele aktivnosti u ovom smjeru, koje treba dalje intenzivirati.
5. Energetski efikasni zamjenski termoblokovi u postojećim TE u BiH, uz visokoefikasnu kogeneraciju i korištenje biomase kao sekundarnog goriva, mogu reducirati godišnju emisiju $CO_2$ za iznose iskazane u milionima tona, i kao takvi mogu poslužiti kao podrška održivoj tranziciji BiH u periodu do 2050. te ispunjenju nacionalnog klimatskog plana. Za razliku od zamjenskih termoblokova, nove TE na nekim novim lokacijama povećavaju emisiju $CO_2$, te kao takvi mogu biti suprotni ciljevima nacionalnog klimatskog plana.
6. Podrška tranziciji se može uspostaviti i revitalizacijom i modernizacijom nekih od postojećih termoblokova koji će ostati u pogonu prema Nacionalnom planu smanjenja emisija - NERP BiH, čime će se tim blokovima, energetski efikasnijim i okolinski prihvatljivijim u odnosu na sadašnje stanje, poboljšati performanse, smanjiti emisije i produžiti životni vijek do kraja tranzicijskog perioda. Ova revitalizacija/modernizacija podrazumijeva implementaciju inovativnih tehnologija i izradu programa revitalizacije baziranih na prethodno obavljenim ekspertnim mjerenjima i analizama.
7. Dugoročni razvoj elektroenergetskog sektora će uveliko ovisiti o tržišnim uslovima, a to se odnosi i na intenzitet implementacije projekata na obnovljive izvore, razvoj decentraliziranog snabdijevanja energijom, a oslanjaće se i na uvezivanje elektroenergetskog sektora sa sektorima toplinarstva (grijanje i hlađenje), saobraćajem (elektromobil-

nost), poljoprivredom, šumarstvom, industrijom, kao i ukupnim razvojem inovativnih tehnologija.

8. Dugoročni razvoj proizvodnog portfolija u BiH treba koncipirati tako da se u u realnim vremenskim okvirima dominacija u sve većoj mjeri prepušta obnovljivim izvorima. U samom tranzicijskom periodu zamjenski kogenerativni blokovi, dijelom bazirani na kosagorijevanju biomase (postojeći i zamjenski blokovi EPBiH, kao i neki drugi blokovi u postojećim TE u BiH), neophodni su kako bi se obezbijedio kontinuitet isporuke električne energije po prihvatljivim cijenama svim stanovnicima BiH, održala energijska neovisnost u što većoj mjeri, ali i obezbijedila okolinski i ekonomski prihvatljiva toplotna energija iz tih kogeneracijskih postrojenja.
9. Koncept tranzicije u narednih 15-ak godina treba da uključuji implementaciju zamjenskih kogenerativnih visokoefikasnih termoblokova, intenzivnu izgradnju proizvodnih jedinica na obnovljive izvore, prvenstveno na intermitentne resurse uz koje će neophodno biti paralelno razvijati adekvatne balansne jedinice/opcije, zatim integraciju različitih koncepata hibridnih sistema sa mogućnošću skladištenja energije, ali i implementaciju biogoriva u procesu kosagorijevanja sa ugljem.
10. Iskorištenje biomase kao drugog goriva u termoelektranama je poslovna prilika koja pruža mogućnost dugoročnoe upotrebe domaćih resursa za proizvodnju električne i toplotne energije, na okolinski i ekonomski održiv način. Ovdje je važna uspostava sistemskog pristupa prikupljanja biomase, odnosno uspostave održivih lanaca snabdijevanja, a paralelno s tim i razvoja tržišta biomase, na čemu se preporučuje intenzivno raditi.
11. Do okončanja modernizacije / puštanja u rad zamjenskih termoblokova, rudnici moraju biti restrukturirani, modernizirani i spremni za dugoročno rentabilno poslovanje, pri čemu te procese treba pokrenuti odmah, kako bi termoelektranama omogućili nesmetan i pouzdan rad u tranzicijskom periodu. To znači da rudnici trebaju biti prilagođeni tranzicijskom planu proizvodnje, te pouzdani za kontinuiranu isporuka potrebnih količina uglja odgovarajućeg kvaliteta i cijene u tranzicijskom periodu do njihovog finalnog zatvaranja. Paralelno je potrebno početi odmah sa uvođenjem back-stop tehnologija u rudnike uglja.
12. U skladu sa prednjim zaključcima, potrebno je uraditi na ekspertskom nivou srednjoročnu energetsku strategiju BiH/FBiH/RS – nacionalni klimatski plan. Pri tome je potrebno uspostaviti saradnju struke i politike, npr. kroz model hibridnih instituta i sl., kako bi energetska strategija bila usklađena sa ciljevima dogovorenim s Energetskom zajednicom, i kako bi bila provodiva odnosno potpomognuta razvojem regulative.
13. Kod planiranja gradnje elektroenergetskih kapaciteta od samog starta voditi računa o interesu lokalne zajednice.
14. Izvršiti potrebnu paralelnu reviziju cijena električne energije, tarifnih sistema, te akcionih planova i mjera energetske efikasnosti, tako da se principijelno ne povećaju troškovi korištenja energije privrede i građana, a da se povećaju prihodi Elektroprivrede BiH i rudnika uglja u BiH.
15. U sve nabrojane aktivnosti uključiti sopstvenu nauku i struku, sve raspoložive ali i nove naučno-istaživačke kapacitete i infrastrukturu, povezane, usmjerene i fokusirane na prioritetna i relevantna nučno-stručna istraživanja primjenom savremenih metoda, te edukaciju budućih stručnjaka koji će preuzeti odgovornost za realizaciju zacrtanih ciljeva eneregtke tranzicije BiH u narednim dekadama.

# 4. PRILOZI: SLIDE PANELI / APPENDICES: SLIDE PANELS

## SLIDE PANELI / SLIDE PANELS


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# Electricity Market Germany

**- Renewables vs. Dispatchable Power Plants -**

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**Pespectives of thermal power plants in energy transition, Sarajevo, November 21st, 2019**

José Gomes, Corporate Development

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- Outlook 2035 on Power Production in Germany
- Production structure of Wind- und Solar
- Flexibilities on lignite and hard coal
- Outlook on Dispatchable Units in Germany 2035



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## VPC GmbH at a glance

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**34 million euros**
Sales

**Know-How**
Practice-oriented planning based on many years of operating experience




**~ 1000 Projects**
per year

**6 Offices**
worldwide



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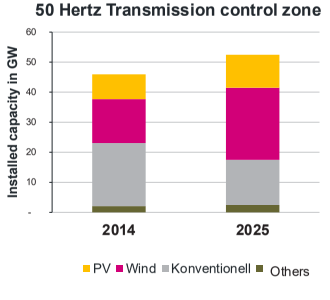
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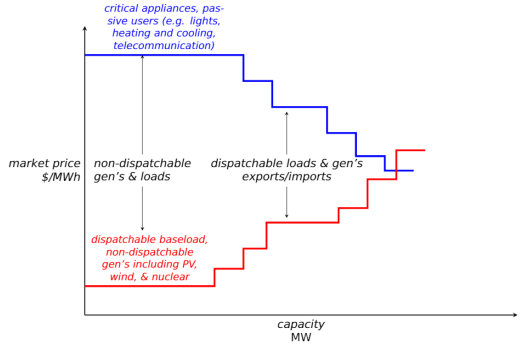
## The German Power Transmission System (TSOs)

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## Electricity Exchange – „Merit Order“ mechanism



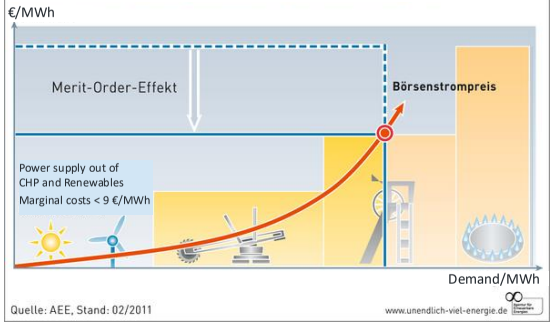

- The **cheapest supply offer** and the **highest price bid** will always win.
- OTC Contracts (e.g. PPA) will still be possible
- The price on the electricity exchange is making the pace for price building, also for OTC – Contracts
- Renewables will drive the changes in the liberalised markets due to higher competition



## The „Merit Order Effect“ (Effect of wind & solar energy)

- The cheapest offer will always win on the commdities exchange. Power is a very unified commodity.
- Prices are depending on marginal costs
- Beyond renewables the „Merit Order“ is mainly depending on costs of fuel and $CO_2$
- Margins of dispatchable units are depending on flexibility

The Renewables are shifting the „Merit Order“ to lower values.
This is reducing the power prices and is named the „Merit Order Effect“.






## Marginal Costs of Power Plants – Need for Trading

The Marginal costs are mainly consisting of:

- Fuel costs
- Fuel related additional costs
  (Transport, Handling, Interests, Transport insurance, collateral, Interests, fees and levies)
- Costs due to flue gas cleaning
  (probably reduced by benefits of selling ashes, gypsum or ammonium sulfate)
- Costs of $CO_2$ – Certificates incl. related purchase costs
- All other variable costs and benefits that goes along with the supply of electricity.
- Finally, system costs of power reduction (accelerated aging of components, loss in efficiency, etc.)



## Trading: „There is always an additional penny in“

Important in liberalised Markets: Support of power plants by Trading

- Planning of production: → At least Weekly for the next 8 days, daily for the two-days after.
  → Further on, daily calculation and planning of notification for Day Ahead Market.
  → Intraday trading for corrective actions → All Power Plants will need trading support.
- Trading support: Don't produce electricity, if you can make or save more money by using someone elses production „Buy cheap and sell more expensive“→ use also cross border deliveries
- Additional gains by improving product (and increasing risk exposure!).
  → e.g. selling weekly, monthly or yearly products, but filling it in only partly by own deliveries
- Trading to mitigate own and third party trading risks → e.g. futures and options (derivative trading)
- Supply of control power to the TSO and balancing power for the own BRP or third parties

**Finally:** Selling power is only one of the products you can make money with.
The other sources of earnings are related to dispatchability and flexibility.

## Effects of renewables on the transmission system

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**Trend**

- Loss of inertia within the grid an therefore additional demand for virtual inertia → fast reaction storage (e.g. Batteries, Flywheels)
- Decrease in dispatchable generation
- Increasing re-dispatch interventions as long as the grid is not suited to cope with renewables at any time.
- Falling Electricity market prices → "Merit order effect"

**Consequences for the power plant operators**

- Frequent but slow ramping, start-up and shut-down of conventional capacities not only along the demand but also along the availability of wind & solar power
- Rising maintenance costs
- Large reduction of full load operating hours
- Rising costs of dispatchable power generation
- Price fluctuations due to liberalization of markets (e.g. EEX power exchange)
- Falling wholesale prices
- Increasing of losses due to an increasing number of "must run" operating phases
- Increasing (changing) requirements by Federal Network Agency
- Rising operational expenses and efforts for operators (±10MW) in order to maintain margins.



## Overview

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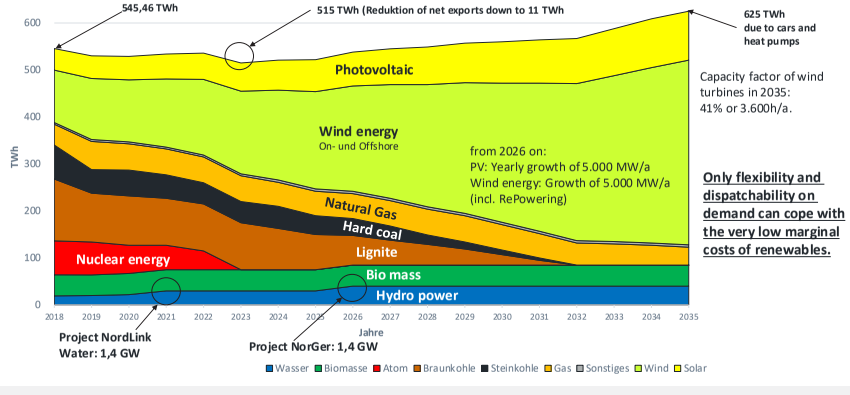

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## Net electricity generation in Germany – Outlook 2035

(public supply only)

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## Overview

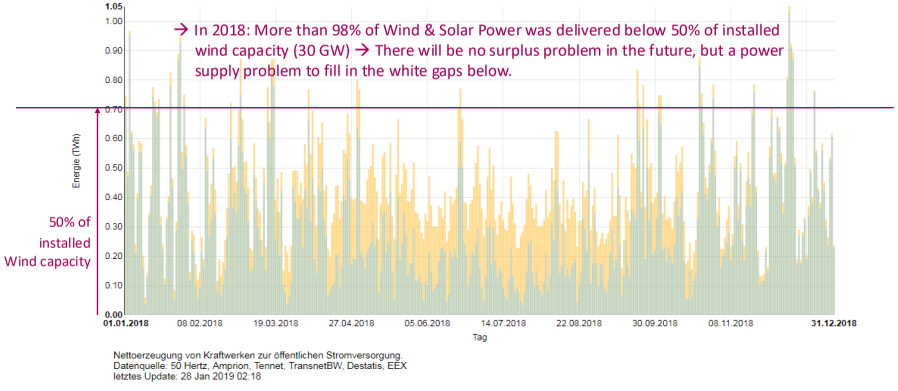
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## Yearly distribution of wind & solar power generation

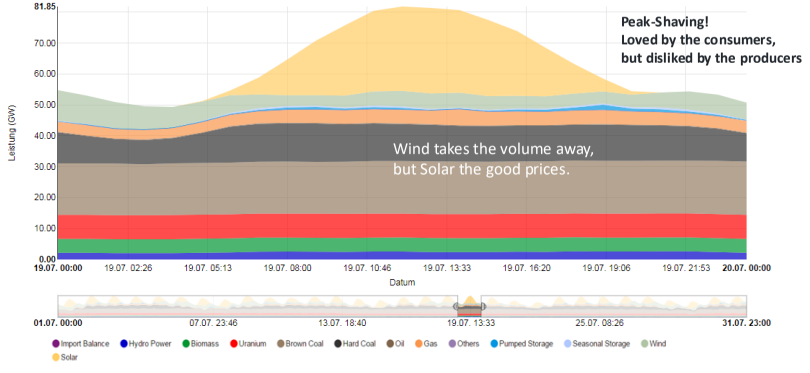
– Wind- & Solar energy production are working mostly complementary -





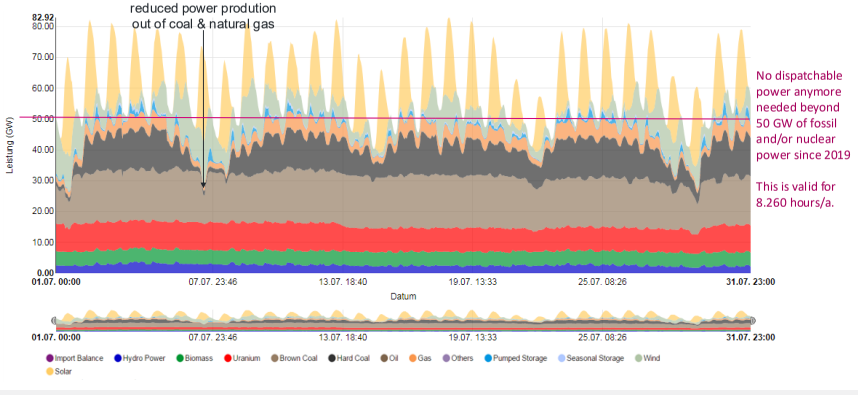

## Typical Summer Day in Germany (July 19th, 2018)

– The peak is going with the sun -






## Power Production in Germany – July 2018



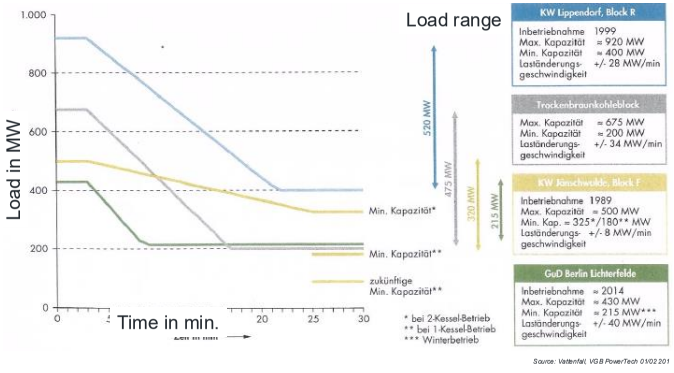



## Overview



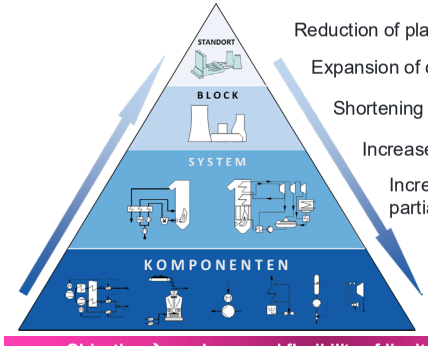
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## Load flexibility comparison of LEAG's and Vattenfalls conventional plants




Source: Vattenfall, VGB PowerTech 01/02 201

## Focal points of Vattenfall's flexGen program



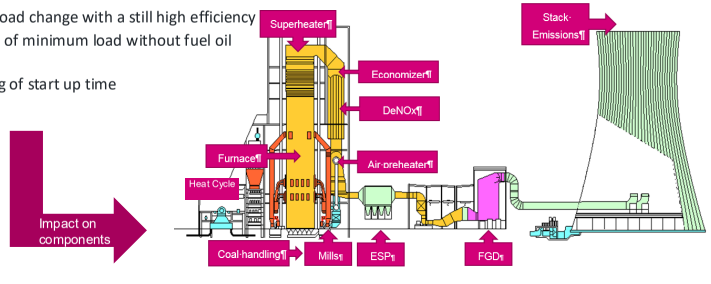

- Reduction of plant minimum load
- Expansion of control range
- Shortening of start-up and shut-down
- Increased load gradients
- Increased efficiency in partial load range
- Effects of increased load changes on lifetime consumption and O&M

**Objective → Increased flexibility of lignite-fired power plants**

## Background – Impact on plant components

Requirements on power plants:

- Increasing number of start-up and shut down process
- Speed of load change with a still high efficiency
- Reduction of minimum load without fuel oil support
- Shortening of start up time






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## The operation modes of future german power supply

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- Distributed along the whole year only three modes will be relevant in 2035:

➔ **Ca. 80 Days/a** ➔ Power Supply only with Wind & Solar will be sufficient
Energy Storages will only align loads and power output throughout the day and provide intertia to the grid in order to ensure the frequency required

➔ **Ca. 265 Days/a** ➔ Along these days the energy output of Wind & Solar will not be sufficient
➔ Dispatchable units between a total of 1 GW – 50 GW will be needed

➔ **Ca. 20 Days/a** ➔ **Very low wind & solar power** (Only relevant from Octobre until end of March)
➔ Very low power output of wind & solar during working days with the related high demand.
➔ The generation of dispatchable units will take over more than 90% of the generation.

In these days additional power of up to 20 GW out of the balancing power reserve of the TSOs maybe needed ➔ This balancing reserve will only be accountable for not more than 0,5% of yearly power generation.



## The future german power supply

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- The dispatchable Units will most probably consist of three components from Summer 2031 on:

➔ **ca. 6 GW of Hydro power (incl. NordLink & NorGer)**

➔ **Ca. 14 GW an flexibilized Biomass power plants**

➔ **Ca. 30 GW of Natural Gas- and oil power plants**

} **„Energy only“ - Market**

➔ **Autumn & winter time (Octobre 1st until March 31st): Up to 20 GW out of TSOs balancing power. This is not needed during Spring and Summer time.**

**The dispatchable Units will supply up to 50 GW, but only appr. 20% of the yearly energy needed.**
➔ 2/3 of that Energy will belong to Hydro and Biomass with only up to 20 GW
➔ 1/3 will belong to Natural gas with up to 30 GW + 20 GW of gas and/or oil turbines.



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VENTURE THE IMPOSSIBLE
TO ATTAIN THE BEST

PROF. CLAUDE DORNIER

Towarzystwo Gospodarcze
Polskie Elektrownie

# *Impact of EU environmental regulations on energy sector transition*

*Michał Jabłoński*
*deputy director on environment protection*





## *Agenda*

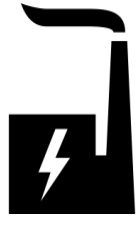
1 TGPE – about us
2 Polish energy sector
3 EU Environmental requirements
4 New lignite power plant
5 Impact of Renewables
6 Conclusions





## About us

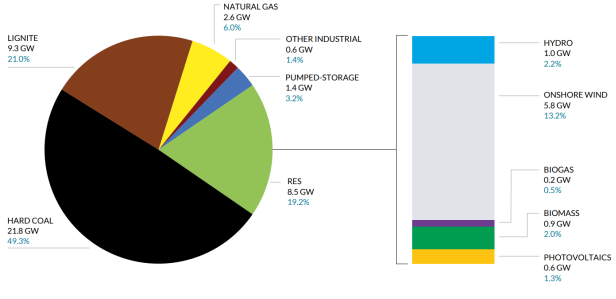
- 1990 - the establishment of the Polish Power Plants Association
- Members – power plants:
  - central dispatch units and others
  - 12 companies, total c.a. 25 GW - 71% of the Polish power system
  - lignite, hard coal, biomass, gas tpp and CHP plants
  - Popular units: 200MW, 360MW, FBB, new supercrticial
- Cooperation with power industry to initiate technical progress
- Participation in legislative process
- Personnel training and promotion
- Representation of system power plants towards central authorities







## *Polish energy sector in 2018*



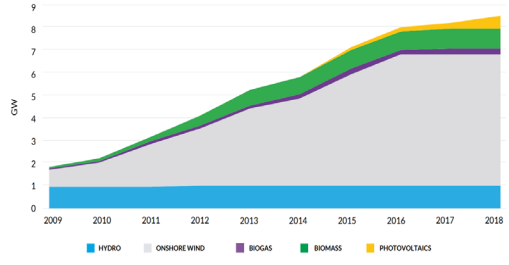

Source: based on data of the Agencja Rynku Energii S.A. (ARE).
As of 31.12.2018

- In the last 12 years share of lignite & coal decreased by 11 %
  - 2005 - 90 %
  - 2017 - 78,4%
- The share of installed capacity of gas units increasing
- The installed capacity of photovoltaic panels increased by more than 80% year-to-year

Source: Forum Energii

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## Polish energy sector in 2018




Source: based on data of ARE.

Changes in installed RES capacity

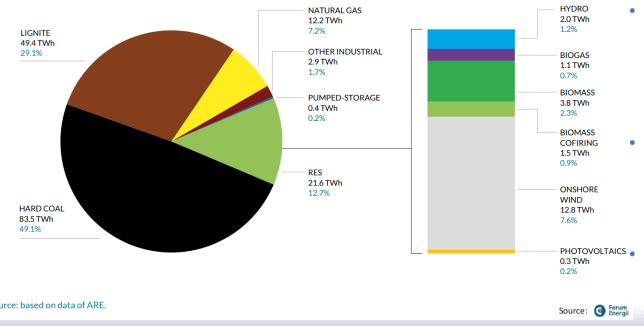
- The installed PV capacity tripled to 560 MW in 2016-18. Currently – 1 GW
- Other renewable sources development is halted since 2016.

Source: Forum Energii



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## Polish energy sector in 2018




Source: based on data of ARE.

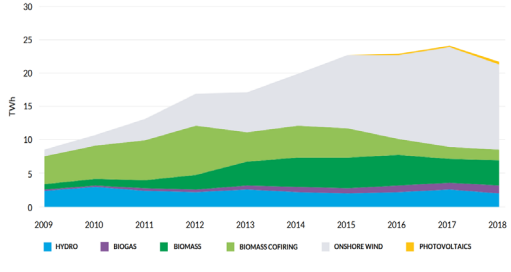
Source: Forum Energii

- Coal is the most important fuel in electricity production - its share was 78.1% compared to 78.4% in 2017.
- The importance of gas is growing. Its share in the energy mix was 7.2% compared to 5.6% in 2017.
- The share of RES in electricity production decreased to 12.7% from 14.1% in 2017.



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## Polish energy sector in 2018




Source: based on data of ARE.

Changes in installed RES production

- In 2018, the lowest production and the lowest share of RES in the mix after 2014 were noted.
- The decrease in production from onshore wind power plants is related to unfavourable legal regulations and less wind.

Source: Forum Energii



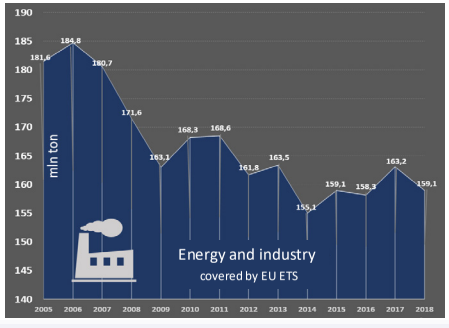
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## Polish energy sector in 2018

- The share of imports in covering domestic energy needs is increasing. Record imports of electricity, coal and gas were noted.
- Energy mix diversification is progressing towards greater utilization of gas units.
- The share of gas in the energy mix is growing, last year it amounted to 7.2%, compared to 5.6% in 2017.
- The import of hard coal has tripled and covers about a quarter of domestic demand.
- In 2017, greenhouse gas emissions in Poland increased by 4% compared to 2016.
- Emissions only in the Energy sector remained unchanged in the last year.

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## Polish energy sector in 2018



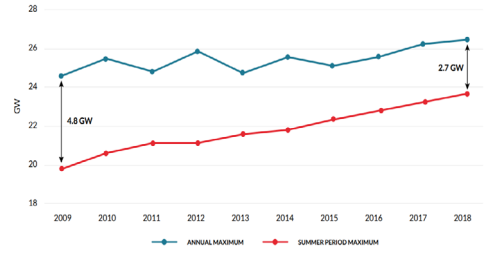

GHG emissions

- In 2017, total greenhouse gas emissions increased by 16 million tonnes or about 4% compared to the previous year.
- Emissions from the power sector decreased in 2018 by 2,5% compared to 2017.



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## Polish energy sector in 2018




Source: based on data of the Polskie Sieci Elektroenergetyczne S.A. (PSE).

Change in peak power demand

- The annual maximum peak power demand in the Polish system is growing - in 2018 it reached a new record level of 26.45 GW.
- The problem of rapidly growing peak power demand in summer is worsening.

Source:



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## EU Environmental requirements

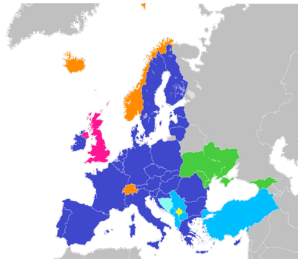
- Independent from CO2 and climate policy
- Pollutants affecting the environment and health:
  - continues tightening of existing emission limit values -ELVs (SO2, NOx, dust)
  - New ELVs: mercury, HCL/HF and others
- They must be set in the integrated permits – <u>non-compliance leads directly to stopping of operation – there is no „trading scheme".</u>
- BATc - EC decision – installations have to comply with BAT within 4 years from date of publication in OJEU – 17.08.2021



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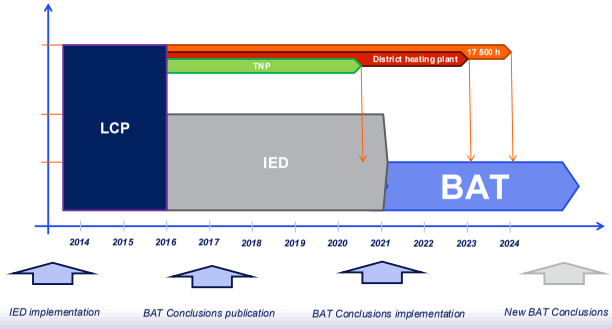
## EU Environmental requirements

- First step – Accession to EU
- Special provisions in Polish Accession Treaty (2004) for energy & industry sectors (TA App. XII, Part 13, let. D, sec. 2 let. b and c)
  - 6 years to adapt integrated permit system based on BAT
  - SO2, dust and NOx derogation up to 2017 (with decreasing total cap)
  - others
- Accession Treaty provisions have more legal force than the Directives and when used wisely can give sufficient time for adaptation



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## EU Environmental requirements




- 1996 ~~IPPC Directive~~
- 2001 ~~LCP Directive~~
- 2010 Industrial Emissions Directive
- 2015 Medium Combustion Plant (MCP) Directive
- 2017 BAT conclusions for LCP
- Next – IED revision, BAT for 20-50MW, new BAT conlusions
- NEC Directive, Mercury regualtions

**What we do:**

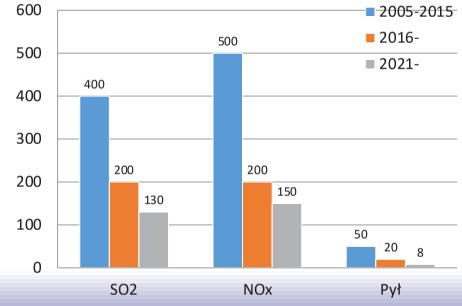
Support MoE with data and knowledge

Limited lifetime derogations, transition plans, district heating, BAT derogations



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## EU Environmental requirements




- Tightening of existing standards (SO2, NOx, dust)
  - Coal-fired installation above 500MW
- For new plants requirements almost 2 times stricter
- Less demanding requirements for peak-load plants (1500 h/y)
  - However: lack of economic mechanisms to compensate such a short time operation



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## EU Environmental requirements

**All member states of EU voted in regard to adoption of new air pollution limits – known as BREF**

- 28th of April 2017 in Brussels
- **28 member states**

**28** member states
Minimum "Yes" required for adoption: (55%) 16

| 20 | 8 | 0 |
|---|---|---|
| Yes | No | Abstain |

% Population
Minimum "Yes" required for adoption: 65%

| 65.14 | 34.86 | 0.00 |
|---|---|---|
| Yes | No | Abstain |

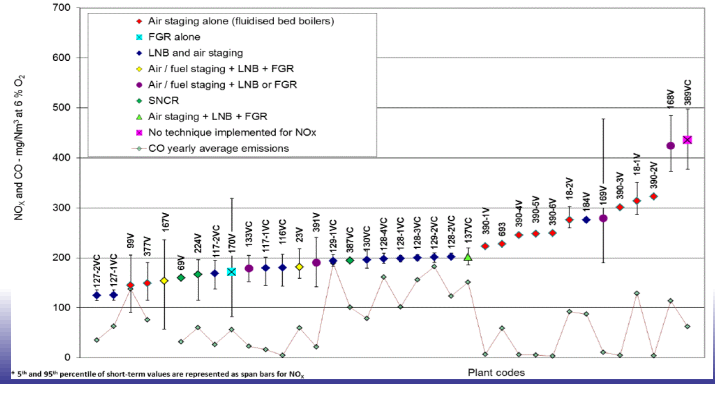





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## EU Environmental requirements

**Coal-fired fluidised bed boilers and lignite-fired boilers of > 300 $MW_{th}$**
**$NO_x$ - CO emission concentrations - Yearly averages***
**BP 1.3.3.2.4 - BATc table 10.3**




* 5th and 95th percentile of short-term values are represented as span bars for $NO_x$

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## EU Environmental requirements

**Poland technical objections to BATc:**

- NOx for lignite – incorrect selection of data to tighten ELVs and force to SCR/SNCR
- Hg for lignite - incorrect selection of data – preference for lower periodic measurement results over higher results from continuous monitoring,
- HCl for coal with high chlorine content – lack of data, not taking into account the specificity of fluidized bed boilers,
- Peak-load plants – do not fully take into account the specifics of the operation (small data base).

**Currently waiting for Court of Justice of the European Union to set date of hearing (for almost 2 years…)**



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## EU Environmental requirements

| Thermal power (with aggregation rule) MWt | | IED [mg/Nm³] | BATAELs [mg/Nm³] | |
|---|---|---|---|---|
| | | | Yearly av. | Daily av. |
| $SO_2$ | 50-100 | 400 | 360 | 400 |
| | 100-300 | 250 | 200 | 250 |
| | 300-500 | 200 | 130 PC<br>180 FBC | 205 PC<br>220 CFB |
| | >500 | | | |
| NOx | 50-100 | 300 | 270 | 330 |
| | 100-300 | 200 | 180 | 210 |
| | >300-500 | | 150 PC węgiel kamienny<br>175 FBC oraz PC węgiel brunatny | 200 PC węgiel kamienny<br>220 FBC oraz PC węgiel brunatny |
| Pył | 50-100 | 20 | 18 | 28 |
| | 100-300 | | 14 | 25 |
| | 300-1000 | | 12 | 20 |
| | >1000 | | 8 | 14 |
| HCl | <100 | | 10/20 | - |
| | >100 | | 7/20 | - |
| HF | <100 | | 6/7 | - |
| | >100 | | 3/7 | - |
| Hg | <300 | | 9 kamienny<br>10 brunatny | |
| | >300 | | 4 kamienny<br>7 brunatny | |

BAT-AELs

Units working more than 1500h/y

Existing before 7 Jan 2014



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## EU Environmental requirements

| Thermal power (with aggregation rule) MWt | | IED [mg/Nm³] | BATAELs [mg/Nm³] | |
|---|---|---|---|---|
| | | | Yearly av. | Daily av. |
| $SO_2$ | 50-100 | 800 | | 400 |
| | 100-300 | 800 | | 250 |
| | 300-500 | 800 | | 220 PC<br>220 CFB |
| | >500 | | | |
| NOx | 50-100 | 450 | | 330/340 |
| | 100-300 | 450 | | 210/340 |
| | >300-500 | | | 220/340 PC węgiel kamienny<br>220 FBC oraz PC węgiel brunatny |
| Pył | 50-100 | 30 | | 28 |
| | 100-300 | 25 | | 25 |
| | 300-1000 | 20 | | 20 |
| | >1000 | | | 14 |
| HCl | <100 | | 20 | - |
| | >100 | | 20 | - |
| HF | <100 | | 7 | - |
| | >100 | | 7 | - |
| Hg | <300 | | 9 kamienny<br>10 brunatny | |
| | >300 | | 4 kamienny<br>7 brunatny | |

BAT-AELs

Units working less than 1500h/y

Existing before 7 Jan 2014



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## EU Environmental requirements

| Thermal power (with aggregation rule) MWt | | IED [mg/Nm³] | BATAELs [mg/Nm³] | |
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| | 100-300 | 800 | | 250 |
| | 300-500 | 800 | | 220 PC<br>220 CFB |
| | >500 | | | |
| NOx | 50-100 | 450 | | 330/340 |
| | 100-300 | 450 | | 210/340 |
| | >300-500 | | | 220/340 PC węgiel kamienny<br>220 FBC oraz PC węgiel brunatny |
| Pył | 50-100 | 30 | | 28 |
| | 100-300 | 25 | | 25 |
| | 300-1000 | 20 | | 20 |
| | >1000 | | | 14 |
| HCl | <100 | | 20 | - |
| | >100 | | 20 | - |
| HF | <100 | | 7 | - |
| | >100 | | 7 | - |
| Hg | <300 | | 9 kamienny<br>10 brunatny | |
| | >300 | | 4 kamienny<br>7 brunatny | |

BAT-AELs

Units working less than 500h/y

Existing before 7 Jan 2014

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## EU Environmental requirements

Challenges:

- NOx: SCR for existing hc plants (< 150 mg/Nm3) or operating in peak-load mode; SNCR for existing lignite plants (< 175 mg/Nm3) and SCR for new lignite plants
- SO2 & dust: modernizations of FGD for PC boilers to achieve SO2 < 130 mg/Nm3 and ESP
- HCL/HF: very high chlorine content in polish hard coal – wet FGD for fluidised bed boilers
- Mercury: ….



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## EU Environmental requirements

In most cases **lignite** fired plants will have problems to meet 7 µg/m3 (>300MW) without dedicated methods for mercury reduction.

Challenges for Operators: :

- Dedicated mercury reduction techniques (np. activated carbon, halogenated activated carbon, sorbent polymer catalyst etc. ),
- uncertainty and possible problems with managment of flue gas cleaning products contaminated with mercury (f.e. gypsum)

In case of hard coal there is a possibility to meet 4 µg/m3 when using multiple flue gas treatment techniques (np. de-dust, SCR + FGD).
However in some cases it may be necessary to use dedicated methods to reduce mercury – it is highly depend on mercury content in fuel.

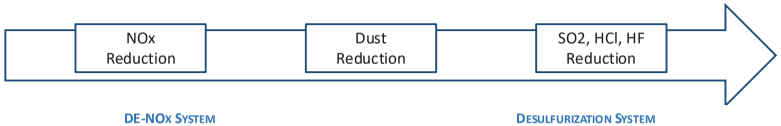
Co-benefit methods:

- Coal: ESP + wet FGD : c.a. 70 % Hg reduction, with proper SCR even 90%,
- While lignite: ESP + wet FGD: 44%)



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## EU Environmental requirements




| DE-NOx System | | Desulfurization System |
|---|---|---|
| SNCR (non-catalytic) | | Semi-dry with additional de-dust |
| SCR (catalytic): High Dust, Low Dust, Tail End | x | Semi-dry with integrated de-dust |
| Hybrid (SNCR + with catalyst) | | Wet |

| Denitrification Reagent | | Desulfurization Reagent |
|---|---|---|
| Ammonia | | Limestone powder |
| Ammonia Water | x | Quicklime or hydrated |
| Urea | | Sodium Sorbents |
| Salmiac | | Other Sorbents |



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## EU Environmental requirements

| Modernisation examples – NOx SNCR | Costs – netto [mln EUR] |
|---|---|
| Block 360 – 390 MWe Primary + SNCR<br>From 400 – 500 mg/Nm$^3$ to 190 – 200 mg/Nm$^3$ | 14,5 – 16,5 |
| Block 220 – 390 MWe (lignite) SNCR<br>From 200 mg/Nm$^3$ to 175 mg/Nm$^3$ | 1,5 – 2,5 |
| Boilers OP – 100,OP – 140, OP – 140, WP – 70 Primary+ SNCR<br>From 500 – 600 mg/Nm$^3$ to 190 – 200 mg/Nm$^3$ | 2,7 – 4,5 |
| **Modernisation examples – NOx SCR** | |
| Blocks 460 – 550 MWe<br>From 500 – 600 mg/Nm$^3$ to <150 mg/Nm$^3$ | 25 – 40 |
| Blocks 360 – 390 MWe<br>From 500 – 600 mg/Nm$^3$ to <150 mg/Nm$^3$ | 16,2 – 19,5 |
| Blocks 200 – 360 MWe,<br>From 500 – 600 mg/Nm$^3$ to <150 mg/Nm$^3$ | 12 – 15,5 |
| Boilers OP – 380, OP – 430, WP – 200<br>From 500 – 600 mg/Nm$^3$ to <150 mg/Nm$^3$ | 8,5 – 10,5 |



Source: Energopomiar - https://www.energopomiar.com.pl/

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## EU Environmental requirements

| | Scenario A | Scenario B | Scenario C | Scenario D |
|---|---|---|---|---|
| BAT-AELs | lower | upper | upper | upper |
| Entry into force | 2021 | 2021 | 2021 | 2023 |
| Drogation 15.4 | - | - | Yes | - |
| Capex [mln EUR] | 4 054 | 2 080 | 2 080 | 2 080 |
| Fixed operational costs [thous. EUR/a] | 141 744 | 117 444 | 117 444 | 117 444 |
| Variable operational costs [kPLN/a] | 275 588 | 241 033 | 241 033 | 241 033 |
| Increase in electricity prices [PLN/MWh] | 4,15 | 2,67 | 2,67 | 2,67 |
| Technical ability of modernization in 4 years. | No possibility for the whole sector | No possibility for the whole sector | No possibility for the whole sector | Yes. |
| Summary | Worst case scenario | Most likely scenario | Optimistic scenario | Rather unlikely scenario |

BAT adaptation cost scenarios (2015)



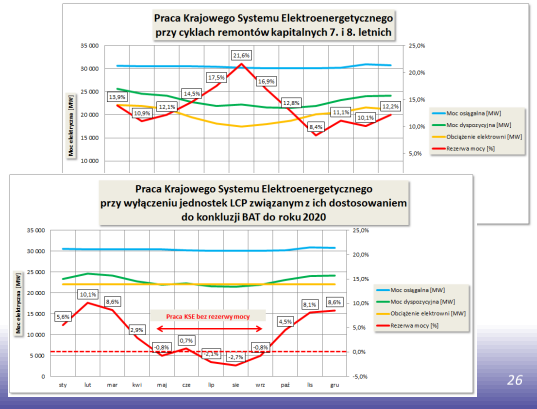
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## EU Environmental requirements

Lack of necessary reserves to withdrawal in order to meet BAT in 4 years.

**In discussion with EC we pointed black-out risk.**

Key issue: more time allowing spread modernizations over time.






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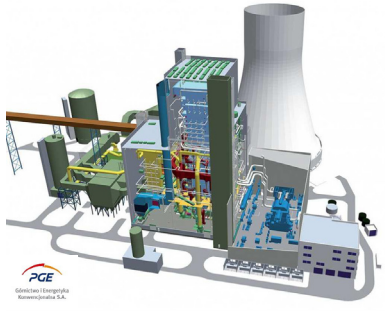
## New lignite plant

**Block 7 PGE Turów PP**

- Contract: July 2014
- Commissioning: Oct 2020
- General Contractor: Mitsubishi Hitachi Power Systems, Tecnicas Reunidas SA and Budimex S.A.
- Net rated power - 446 MWe
- Nominal net efficiency - 43%
- Block availability – c.a. 91%
- boiler maximum capacity up to 1270 t / h
- block technical minimum - 40%

**Key issue – changing environmental requirements during investment process**

Net cost: c.a. 800 mln EUR





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## New lignite plant

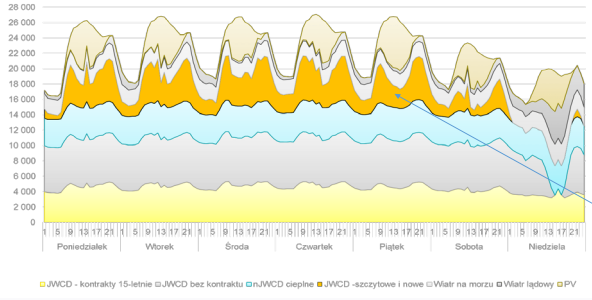
| | | Units | Yearly av. |
|---|---|---|---|
| 1. | $SO_2$ | $mg/m^3_{usr}$ | ≤ 75 |
| 2. | $NO_x$ | $mg/m^3_{usr}$ | ≤ 85 |
| 3. | PM | $mg/m^3_{usr}$ | ≤ 5 |
| 4. | $NH_3$ | $mg/m^3_{usr}$ | ≤ 3 |
| 5. | HCl | $mg/m^3_{usr}$ | ≤ 3 |
| 6. | HF | $mg/m^3_{usr}$ | ≤ 2 |
| 7. | Hg | $\mu g/m^3_{usr}$ | ≤ 4 |

| Lignite | [u] | Premogovnik Velenje | Turów |
|---|---|---|---|
| Caloric net value | kJ/kg | 11 300 | 10 650 |
| Ash | % a.r. | 14 | 29 |
| Wet | % a.r. | 36 | 39 |
| Sulphur | % a.r. | 1.4 | 1,4 |

- SO2, HCl, HF - Wet FGD on limestone powder, with high liquid-to-gas ratio;
- NOx – primary (Low NOx Burners, Air Stagging etc.) and designed dedicated SCR - lowest NOx emission from lignite in the world
- PM – ESP (5 zones) + WetFGD
- Hg - ammonium chloride with TRAC catalyst on SCR, WetFGD and as reserve – activated carbon with ESP
- Almost no wastewater (treatment and re-use) - microfiltration, high pressure reverse osmosis, salt crystallization

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## Impact of Renewables




**Predicted coverage of the weekly demand in 2030:**

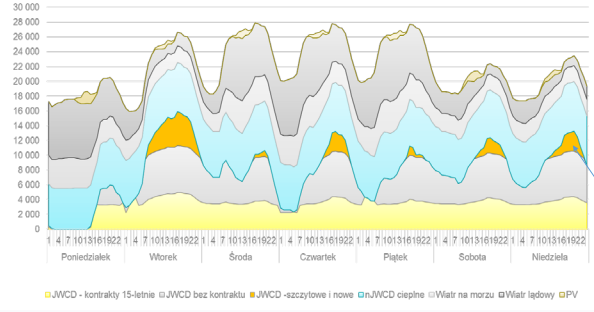
- Summer
- average wind generation

| |
|---|
| PV |
| Onshore wind |
| Offshore wind |
| **Peak and new CDU** |
| Other thermal units |
| No contr. CDU |
| Long term contr. CDU |



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## Impact of Renewables




**Predicted coverage of the weekly demand in 2030:**

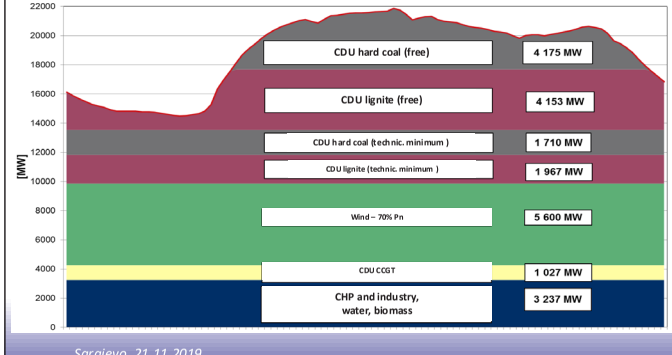
- winter
- average wind generation

| |
|---|
| PV |
| Onshore wind |
| Offshore wind |
| **Peak and new CDU** |
| Other thermal units |
| No contr. CDU |
| Long term contr. CDU |



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## Impact of Renewables




**Predicted in 2016 coverage of the daily demand in 2020:**

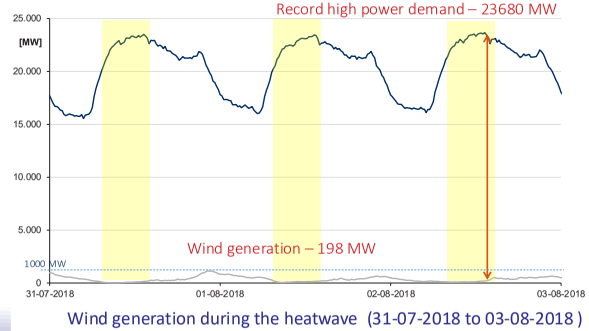
- summer
- high wind generation

Source: PSE 2016



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## Impact of Renewables




Wind generation during the heatwave (31-07-2018 to 03-08-2018 )

**Summer problems with reliability of wind**

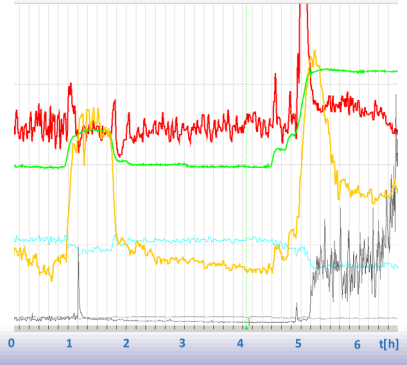
- cooling water shortages – lower thermal PP generation
- any working block malfunction will be a serious problem for the system operator



Source: PSE S.A.

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## Impact of Renewables




Impact of load changes on emission - tests
Lignite unit 300MW

Can affect daily averages – SO2 and NOx

Bigger margin and reserve is needed

- Power
- NOx
- $SO_2$
- CO
- $O_2$ [0 ÷ 25 %]
- PM

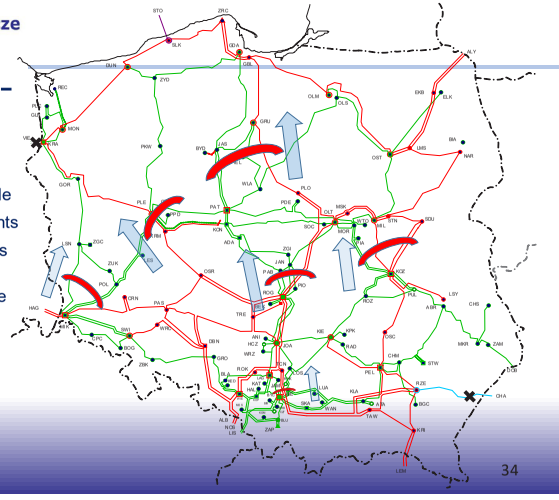


Source: Energopomiar - https://www.energopomiar.com.pl/

Towarzystwo Gospodarcze
Polskie Elektrownie

**Problems for system operator – low wind generation**

- Power flow direction : S to N
- Export to SWE and LIT impossible
- Forced operation of northern plants
- Pumped storage (PSH) reserve is needed
- Some parts of grid are impossible to work at



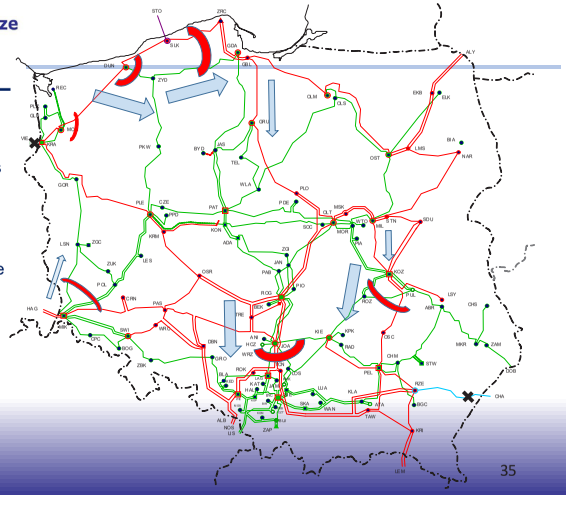


Source: PSE S.A.

Towarzystwo Gospodarcze
Polskie Elektrownie

**Problems for system operator – high wind generation**

- Changes of power flow directions
- Import from SWE impossible
- Forced operation of southern plants
- Some parts of grid are impossible to work at
- Power balancing is difficult





Source: PSE S.A.

Towarzystwo Gospodarcze
Polskie Elektrownie

## Conclusions

- Technology is not a problem – environmental requirements are achievable - its affecting investment profitability, risks etc. – in the same time GHG emissions cost (ETS) are rising (up to 60 eur/t in 2040 – or more)
- Good cooperation with government is the key – emissions limits will be stricter every 6-8 years and we have to deal with it
- Increasing share of RES is forcing thermal units to work in regulatory regime with extreme various loads – which creating technical and emission problems
- Most important issue – to adapt market mechanisms that will cover the costs of peak-load and mid-merit plants
- Best peakers – gas turbines or old end-of-life coal units
- Competence problem - aging technical staff, outsourcing

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CPERI
Chemical Process and Energy Resources Institute

# The role of lignite in the Greek energy system: from the '50s till 2028(?)

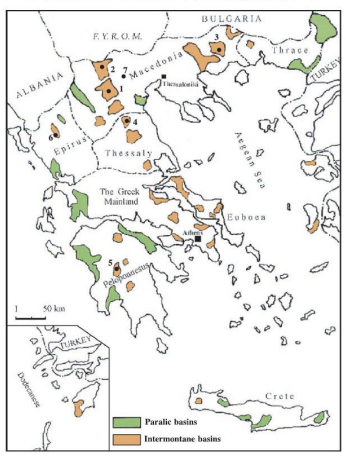
**Perspectives of Thermal Power in Bosnia and Herzegovina in Energy Transition**
**ANUBiH, Sarajevo, 21st November 2019**

**Emmanouil Karampinis*, Dionysios Giannakopoulos, Panagiotis Grammelis, Emmanuel Kakaras**
** Tel.: +30 211 1069518, Email : karampinis (at) certh.gr*

## Contents

- ✓ Greek lignite: resources, reserves & fuel properties
- ✓ Public Power Corporation, lignite production, cost & role in the Greek energy system
- ✓ The mining areas: Aliveri, Western Macedonia, Megalopoli
- ✓ The Greek lignite Thermal Power Plants
- ✓ Future role of lignite?
- ✓ Ptolemaida V
- ✓ Final remarks

## Greek lignite: resources & reserves




**Lignite resources:** 4.6 billion tons

**Lignite reserves:** 2.9 billion tons

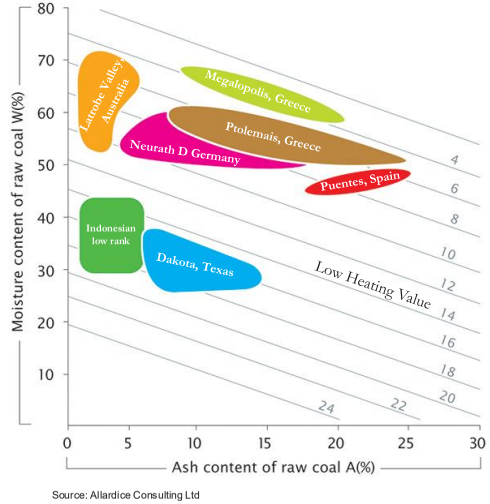
- ✓ (1), (2) Western Macedonia (Ptolemaida – Amyntaio – Florina): 1.5 billion tons / 80 % of production
- ✓ (3) Drama: 900 million tons / Not exploited
- ✓ (4) Elassona: 170 million tons / Not exploited
- ✓ (5) Megalopoli: 225 million tons / 20 % of production

Around 30% of the total lignite reserves have been extracted to date

+ Peat reserve in Philippi: 4 billion $m^3$

Source: EURACOAL

## Greek lignite: fuel properties



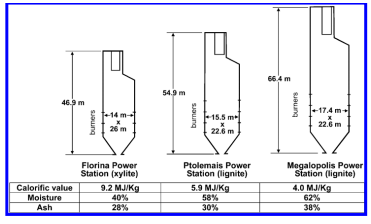

Source: Allardice Consulting Ltd

# Greek lignite: fuel properties

| Coal basin | LHV (MJ/kg) | Moisture (% wt ar) | Ash (% wt ar) | C (% wt ar) | S (% wt ar) |
|---|---|---|---|---|---|
| Florina | 5.4 – 9.8 (9.2) | 38.1 – 43.8 (40) | 9.9 – 28.4 (16.8) | 16.0 – 45.9 (27.1) | 0.4 – 1.2 (0.7) |
| Ptolemais / Amyntaio | 4.6 – 6.5 (5.9) | 43.4 – 60.6 (56) | 6.7 – 24.6 (12.8) | 9.4 – 36.0 (18.7) | 0.2 – 0.8 (0.4) |
| Megalopolis | 3.6 – 4.6 (4.0) | 57.5 – 65.0 (60) | 12.3 – 23.5 (14.9) | 12.2 – 22.8 (15.2) | 0.9 – 1.8 (1.2) |

Source: C. Papanicolaou, M. Galetakis, A.E. Foscolos, Quality Characteristics of Greek Brown Coals and Their Relation to the Applied Exploitation and Utilization Methods, Energy & Fuels 2005, 19, 230-239

- ✓ Greek lignite has a high content of limestone, $CO_2$ content ranging from 2 to 7 %
- ✓ CaO in the fly ash contributes to natural delulphurization of the flue gas / negative impact on ESP performance
  - FGD installed only in units with low Ca/S ratios (Florina, Megalopolis)
- ✓ Florina lignite: xylitic content of 16 – 32 % wt ar
- ✓ Amyntaio lignite: high content of abrasive minerals → increased wear in mills & boiler




# Public Power Corporation S.A.

Public Power Corporation S.A.-Hellas

*Always by your side*

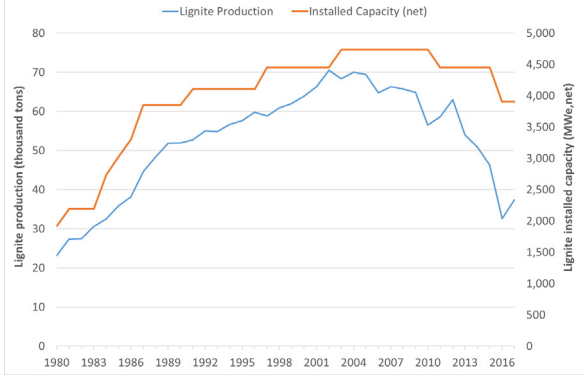
- ✓ Established in 1950
- ✓ 1957-1963: acquisition of municipal & private electricity producers in Greece – sole electricity producer
- ✓ Law 2773/1999: liberalization of the electricity market
- ✓ 2001: conversion into societe anonyme, wholly owned by the Greek state
- ✓ Currently, 51.123 % indirectly controlled by the Greek state

| YEAR ENDED 31st DECEMBER | 2018[1],[2],[3] | 2017[2],[3] | 2016 |
|---|---|---|---|
| Installed Capacity (GW) | 11.3 | 12.1 | 12.1 |
| Percentage of Total Installed Capacity in Greece[3] | 54.3% | 59.5% | 60.3% |
| Net Generation (TWh)[4] | 27.4 | 32.6 | 30.3 |
| Generation Market Share[5] (average annual) | 53.8% | 63.0% | 62.7% |
| Electricity sold to end customers (TWh)[6] | 40.9 | 43.8 | 45.6 |
| Supply market share[7] (average annual) | 81.9% | 86.7% | 91.8% |
| Customers (in mil.) | 6.9 | 7.2 | 7.3 |
| Number of employees on payroll | 15,526 | 17,519 | 18,902 |

(1) The years 2017 and 2018 do not include figures for IPTO (whose full ownership unbundling from PPC was completed in 2017).
(2) 2018 does not include the figures for "Lignitki Maritsa S.A." and "Lignitiki Megalopolis S.A."
(3) Installed capacity of PVs household installations is included in the relevant figures.
(4) Net electricity generation equals gross generation of electricity less energy consumed internally in the generating process.
(5) Generation market share is defined as the percentage of the electricity generated by PPC over the total electricity generated in Greece each year.
(6) Including domestic sales and exports.
(7) Supply market share is defined as the percentage of the electricity supplied by PPC to end-customers in Greece over the total electricity supplied to end-customers in Greece each year.

- ✓ Sole owner & operator of lignite TPPs in Greece (3.9 GWe)
- ✓ Major lignite mine operator & producer (some few private producers also operate)
- ✓ Sole owner & operator of large hydro PPs in Greece (3 GWe)
- ✓ Generation assets include natural gas PPs (2.3 GWe), oil PPs (in the non-interconnected islands) and renewables

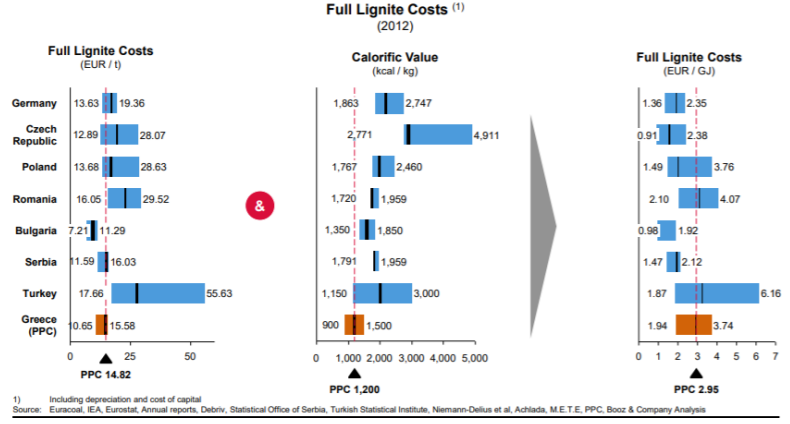
# Lignite production & installed capacity




- ✓ Production peaked in 2012 at 77,678 thousand short tons
- ✓ Greece has now fallen to the 4th place of lignite producers in the EU-28, behind Germany, Poland and Czech

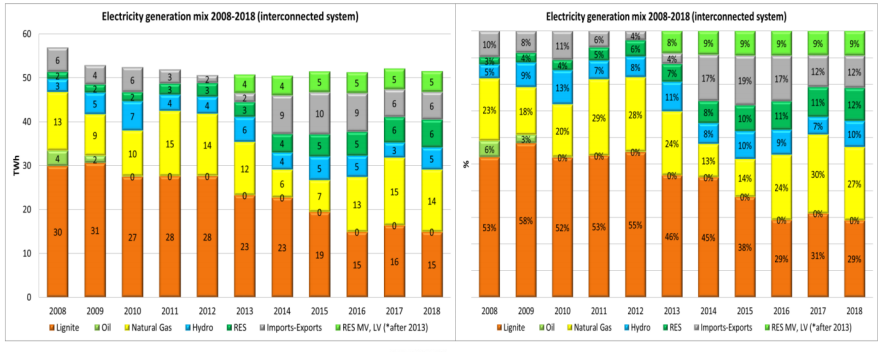
Lignite production data source: https://knoema.com/atlas/Greece/topics/Energy/Coal/Production-of-lignite-coal

# Full lignite cost: the booz&co. study




Source: booz&co. (2014), Understanding Lignite Generation Costs in Europe. Study on behalf of PPC S.A.

# Greek electricity mixture



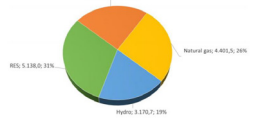



Figure 8: Installed (net) capacity (MW and as a percentage of total capacity) per technology in 2017

# The Aliveri mining area



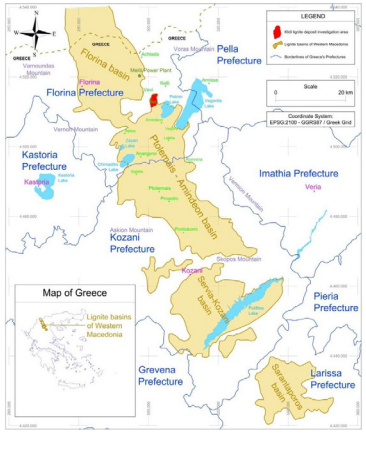


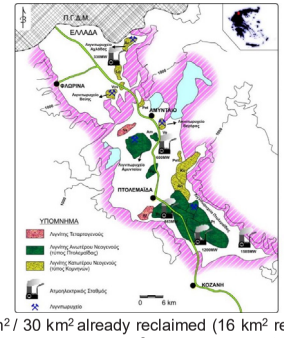


Image sources: http://oryktos.blogspot.com/2014/12/46.html

- ✓ Mentioned by ancient Greek writer Pausanias
- ✓ 1833: first mining operations, aiming at use of lignite at shipyard overs and steamboats
- ✓ 1986 – 1987: first underground mine (closed down due to flooding)
- ✓ 1918: establishment of the Aliveri Mining company (12,849 tons annually)
- ✓ 1949: production increases to 25,000 tons thanks to improved mining methods
- ✓ 1950 – 1951: ownership transferred to the Greek state and Public Power Corporation; establishment of the Aliveri TPP (final output of 230 MW)
- ✓ 1968: explosion takes the lives of 7 workers
- ✓ 1975: start of surface mining exploitation
- ✓ 1981: termination of underground mining
- ✓ 1988: termination of surface mining operations; Aliveri TPP retrofitted to heavy fuel oil firing

# The Western Macedonia mining area




- ✓ 160 km$^2$ / 30 km$^2$ already reclaimed (16 km$^2$ reforested, 10.5 km$^2$ agricultural land, 3 km$^2$ parks, lakes, etc.)
- ✓ Thickness of overburden from 12 to 230 meters
- ✓ Interburden of inert materials
- ✓ Average thickness of extractable lignite layers is 2 meters, the number of which ranges from 20 to 30
- ✓ Overburden-interburden-to-lignite ratio of 5.6 : 1 m$^3$/t

Image Sources: Michalakopoulos et al. (2014). Discrete-Event Simulation of Continuous Mining Systems in Multi-layer Lignite Deposits. 10.1007/978-3-319-12301-1_21

CERTH/CPERI, Dr. N. Koukouzas

# Open cast lignite mining



Image Source: Vasiliki Gemeni, CERTH



Image Source: https://www.lifo.gr/articles/environment_articles/163131

# The Western Macedonia mining area





Top: construction of LIPTOL. Source: Agnar Grødal / kozanimedia

Bottom: Bucket wheel excavator in frozen landscape. Source: PPC S.A.

**Mining area of Western Macedonia ("the Greek Ruhr")**

- ✓ 1920 – 1938: fuel for domestic heating by some local pioneers (G. Pavlidis, K. Adamopoulos, N. Diamantopoulos)
- ✓ 1939: survey of Prof. Kegel, estimating the lignite deposits at 6 billion tons
- ✓ Increased interest by the Greek state; economic studies for exploitation undertaken / transfer of 180 tons of Greek lignite to Germany for testing
- ✓ 1957: inauguration of briquetting plant and 10 MWe TPP of LIPTOL by Bodosakis
- ✓ 1959: transfer of 90 % of LIPTOL shares to PPC
- ✓ 1959 : Start-up of Ptolemaida TPP
- ✓ 1974: Start-up of Kardia TPP
- ✓ 1984: Start-up of Agios Dimitrios TPP
- ✓ 1987: Start-up of Amyntaio TPP
- ✓ 2003: Start-up of Meliti TPP; gross installed capacity reaching 4,395 Mwe
- ✓ 2010: Ptolemaida I enters cold reserve / Ptolemaida V project approved

# The Megalopolis mining area



- ✓ Total depth of 20 – 140 meters
- ✓ Lignite thickness layer ranging from a few centimeters to 5 meters
- ✓ Overburden-interburden-to-lignite ratio of 3.5 : 1 $m^3/t$
- ✓ TPPs using direct firing with partial vapor discharge in order to avoid entry of excess moisture in the boiler (similar system employed in Elbistan, Turkey)

**Mining area of Megalopolis**

- ✓ Known from the early days of the independent Greek state; commercial exploitation was not successful due to low calorific value and idea that quantities were low
- ✓ 1957: new study by the Institute of Geology and Underground Research (I.G.E.Y.) calculated that just the reserves which were visible on the surface were more than 4,000,000 tons per square kilometre
- ✓ 1969: Public Power Corporation S.A. starts mining at the now depleted Thoknia mine (initial production of 4 mil. tons / year); new mining areas later established at Choremi, Marathoussa and Kyparissia
- ✓ 1970: Start-up of Megalopolis I & II
- ✓ 1975: Start-up of Megalopolis III
- ✓ 1991: Start-up of Megalopolis IV
- ✓ 2011: Decommissioning of Megalopolis I & II
- ✓ 2015: Start-up of Megalopolis V gas power plant (811 MWe)

# Greek lignite TPPs (1/2)













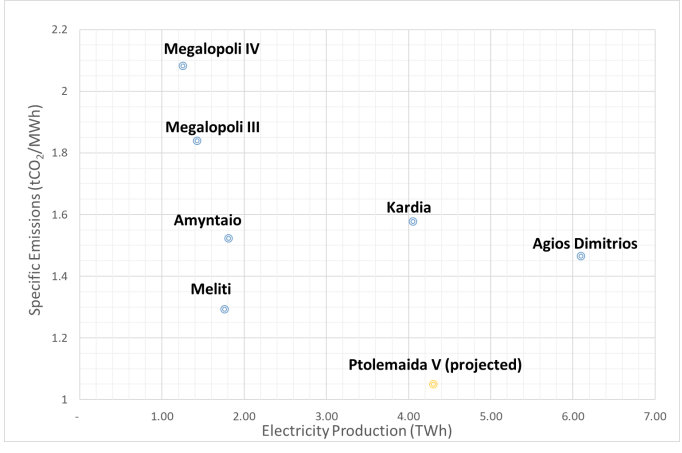
# Greek lignite TPPs (2/2)

| TPP / Unit | Start-up | Gross installed capacity (MWe) | Net installed capacity (MWe) | Thermal Capacity for DH (MWth) |
|---|---|---|---|---|
| Agios Dimitrios I | 1984 | 300 | 274 | N/A |
| Agios Dimitrios II | 1984 | 300 | 274 | N/A |
| Agios Dimitrios III | 1985 | 310 | 283 | 67 |
| Agios Dimitrios IV | 1986 | 310 | 283 | 67 |
| Agios Dimitrios V | 1997 | 375 | 342 | 70 |
| Amyntaio I | 1987 | 300 | 273 | 25 |
| Amyntaio II | 1987 | 300 | 273 | 25 |
| Kardia I | 1975 | 300 | 271 | N/A |
| Kardia II | 1975 | 300 | 271 | N/A |
| Kardia III | 1980 | 306 | 280 | 50 |
| Kardia IV | 1981 | 306 | 280 | 50 |
| Megalopoli III | 1975 | 300 | 255 | 20 |
| Megalopoli IV | 1991 | 300 | 256 | N/A |
| Meliti I | 2003 | 330 | 289 | 70* |
| **Current Total** | | **4,337** | **3,904** | |
| Ptolemaida V* | 2020/2021 | 660 | 615 | 140 |

*Under construction

- ✓ Most of the lignite units have an age of 35 years or more
- ✓ **Amyntaio + Kardia**: in opt-out regime since 01.01.2016; operational extension granted by the Ministry for DH operation
- ✓ **Agios Dimitrios I – IV**: undergoing or considered retrofits (dry FGD, primary measures for NOx reduction) for lifetime extensions
- ✓ **Agios Dimitrios V:** wet FGD planned, in principle could remain operational > 2040
- ✓ **Megalopoli:** Unit III in principle till 2025; Unit IV until mine runs outs (2032)
- ✓ **Meliti:** wet FGD equipped; in principle could remain operational > 2040

# Greek lignite TPPs: specific $CO_2$ emissions




Source: ADMIE – Monthly Bulletins 2017 / ETS registry 2017 verified emissions

# Role of lignite in National Energy and Climate Plan



**Draft National Energy and Climate Plan (NCEP) / submitted January 2019 to European Commission**

- ✓ Role of lignite in the Greek power system decreasing but maintained

| Draft NCEP projections | 2016 | 2020 | 2025 | 2 | 203 |
|---|---|---|---|---|---|
| Lignite installed capacity (GWe,net) | 3.9 | 3.4 | 3.5 | 2.7 | 1.3 |
| Lignite share in electricity production | 30.6% | 25.5% | 17.7% | 16 | |

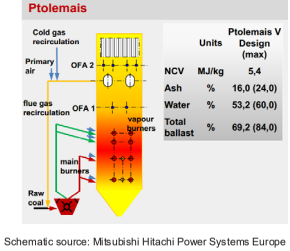



**New Policy – Coal Phase-out by 2028**

- ✓ PM Kyriakos Mitsotakis announced a coal phase-out by **2028** in the UN Climate Action Summit (23rd September 2019)
- ✓ Greece and Germany are so far the only major lignite producers in the EU to set a coal phase-out date; Greece is the only one to have set it before 2030
- ✓ A revised NCEP is currently under discussion and expected to be submitted by the end of 2019

# The "riddle" of Ptolemaida V (1/2)






Schematic source: Mitsubishi Hitachi Power Systems Europe

**Technical characteristics**

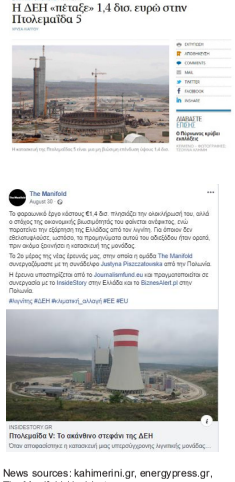
- ✓ Capacity: 660 $MW_e$ (gross), 615.7 $MW_e$ (net) + 140 $MW_{th}$ (district heating)
- ✓ Net electrical efficiency: 41.5 %
- ✓ SH: 603 °C / 258 bara, RH: 610 °C / 52 bara
- ✓ Specific emissions: 1.05 $tCO_2$ / MWh

**Total investment:**

- ✓ 1.4 billion EUR / ~2,270 EUR/$kW_{e,net}$

**Commercial operation expected late 2020 / early 2021**

# The "riddle" of Ptolemaida V (2/2)




News sources: kahimerini.gr, energypress.gr, The Manifold / insidestory.gr

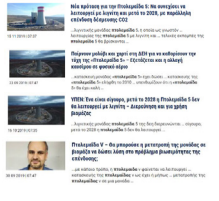
**Investment decision taken in 2010, in a totally different policy and market framework**

- ✓ Rising $CO_2$ prices
- ✓ Exclusion for capacity mechanism (specific emissions > 550 $gCO_2$/kWh)
- ✓ Competition with natural gas units
- ✓ Coal phase-out

- ✓ Payback time of the investment unclear
- ✓ Unit may even generate annual losses with higher $CO_2$ prices

**Lignite operation foreseen till 2028; alternatives are discussed in the public sphere**

- ✓ Natural gas conversion?
- ✓ Conversion to biomass / biomass co-firing?
- ✓ Carbon Capture and Storage?
- ✓ Photovoltaics (?!) / other ?
- ✓ Special reference to be included in revised Greek NCEP



## Final Remarks…

- ✓ Greek lignite is the only major, indigenous fossil fuel resource (so far); its exploitation has played a crucial role in the development of the Greek economy since the 1950s
- ✓ Greek lignite is one of the poorest coals of the world; this has an impact in all aspects of its value chain, from extraction to power production costs
- ✓ Increased share of RES and natural gas in the Greek electricity market AND increasing cost of $CO_2$ have severely limited the profitability of the lignite sector
- ✓ Plans for decreased lignite power generation have been discussed for years; however the announced coal phase-out accelerates the developments and poses more ambitious goals
- ✓ The path for the Greek Coal Regions in Transition is not yet clear… many questions remain unresolved
  - Alternative DH network heat suppliers
  - Fate of ongoing investments (Ptolemaida V), retrofits and land reclamations
  - Serious socio-economic issues for the regions (impact on GDP, employment)
  - Selection of new productive model(s)?

ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA (ANUBiH)

PUBLIC ENTERPRISE ELEKTROPRIVREDA OF BOSNIA AND HERZEGOVINA D.D. – SARAJEVO (EPBiH)

PERSPECTIVES OF THERMAL POWER IN BOSNIA AND HERZEGOVINA IN ENERGY TRANSITION
ANUBiH, Bistrik 7, 71000 Sarajevo, November 21st, 2019

# Izazovi transformacije energetskog sektora Srbije

Prof. dr Miloš Banjac, pomoćnik ministra
Ministarstvo rudarstva i energetike Republike Srbije

## Sadržaj prezentacije

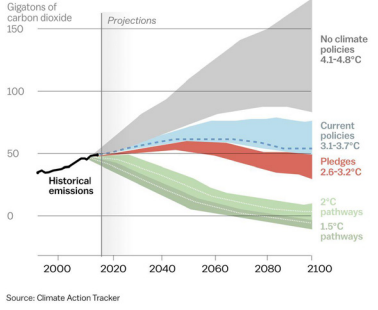
1. Energetska transformacija EU
2. Zahtevi za energetskom transformacijom Srbije
3. Strategija razvoja energetskog sektora Srbije do 2025
4. Mogući scenariji za razvoja energetskog sektora Srbije do 2050
   - Kreiranje softvera za modeliranje razvoja energetskog sektora
   - Analiza stanja energetskog sektora Srbije
   - Razmatrani uticajni faktori
   - Scenariji
5. Rezultati proračuna
6. Zaključci

## 1. Energetska transformacija EU

**Pariski sporazum**

**Trenutna obećanja i politike**

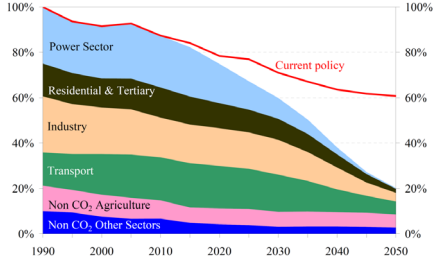
**Emisije GHG gasova**




Source: Climate Action Tracker

### 2050 Energy Strategy

- EU je postavila dugoročni cilj smanjenja emisije GHG gasova do 2050. godine za **80-95% u poređenju sa emisijom iz 1990. godine**

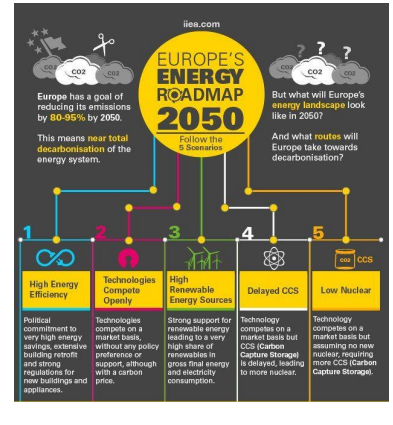



## 1. Energetska transformacija EU

### The Energy Roadmap 2050

Ponudio model tranzicije energetskog sistema na načine koji bi bili kompatibilni sa ovim ciljem smanjenja emisije GHG, uz istovremeno povećanje konkurentnosti i sigurnosti snabdevanja.

- **Povećanje energetske efikasnosti** - smanjiti potrošnju energije za 41% do 2050. godine u poređenju sa 2005-06.
- **Takmičenje tehnologija** na tržišnoj osnovi **bez ikakvih subvencija**, ali sa cenom emisije $CO_2$
- **Povećanje korišćenja OIE** – udeo u potrošnji 75% u 2050 i udeo u potrošnji električne energije 97%.
- **Dekarbonizacija** - hvatanja i skladištenja ugljenika (CCS) ali i prihvatanje nuklearnog energije podstaknute cenama $CO_2$
- **Nema novih nuklearnih** (osim onih koji se trenutno grade)



## 1. Energetska transformacija EU

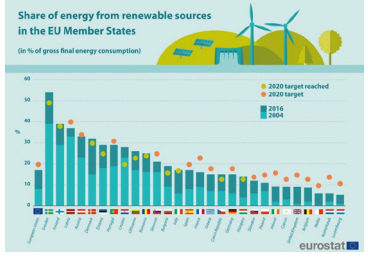
**Sistem trgovine emisionim jedinicama EU** (EU ETS) predstavlja sredstvo za smanjenje emisija gasova sa efektom staklene bašte iz industrijskog sektora na ekonomski efikasan način.

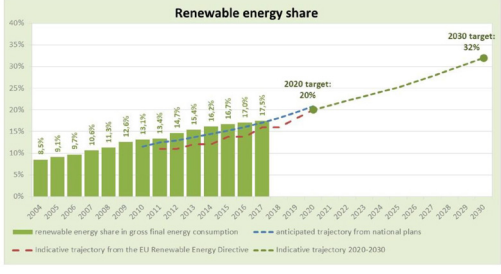
- 2003: Usvajanje EU ETS direktive
- 2005 – 2007: prvi period trgovine (pilot period)
- 2008 – 2012: drugi period trgovine (Kyoto period)
  - Plan Nacionalne alokacije
  - uvođenje besplatnih alokacija
- 2013 – 2020: treći period trgovine
  - uvođenje aukcija
- 2021 – 2027: četvrti period trgovine

"**Clean Energy for All Europeans**" - nov sveobuhvatan okvir energetske politike u cilju prelaska sa fosilnih goriva na čistiju energiju i ispunje obaveze iz **Pariskog sporazuma o smanjenju emisije gasova sa efektom staklene bašte.**

## 1. Energetska transformacija EU

OIE u EU doživeli ogromnu ekspanziju




## 1. Energetska transformacija EU

**The Energy Roadmap 2050**

**2030 FRAMEWORK FOR CLIMATE AND ENERGY —**
AGREED TARGETS

| | GREENHOUSE GAS EMISSIONS | RENEWABLE ENERGY | ENERGY EFFICIENCY | INTER-CONNECTION | CLIMATE IN EU-FUNDED PROGRAMMES | CO2 FROM: |
|---|---|---|---|---|---|---|
| 2020 | -20% | 20% | 20% | 10% | 2014-2020 20% | |
| 2030 | ≤ -40% | ≤ 32% | ≤ 32.5% | 15% | 2021-2027 25% | CARS -37.5% Vans -31% Lorries -30% |

Upwards revision clause by 2030

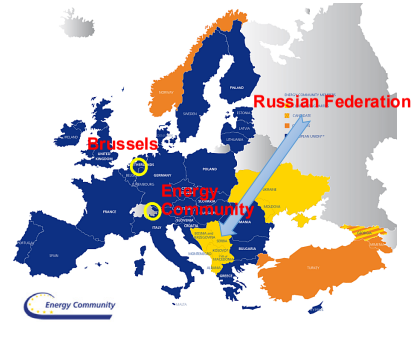
European Commission website https://ec.europa.eu/clima/citizens/eu_en

## 2. Zahtevi za energetskom transformacijom Srbije

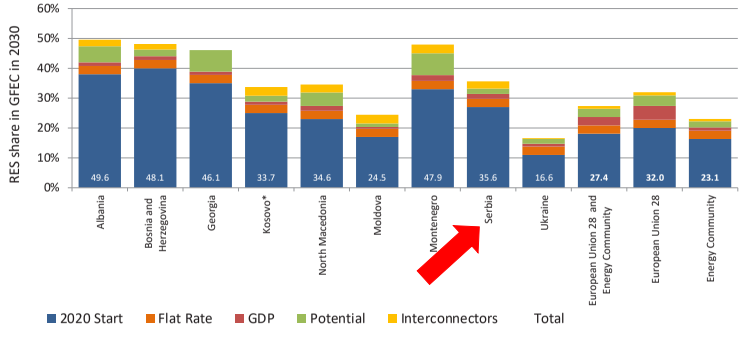
2005 - potpisan Ugovor o osnivanju zajednice;
2006 - ratifikovala ga Skupština Srbije

Potpisnice ugovora su
Evropska komisija (EU) i
Albanija, Bosna i Hercegovina,
Hrvatska, Severna Makedonija,
Srbija, Kosovo*,
Crna Gora ...

Moldavija,
i Ukraina

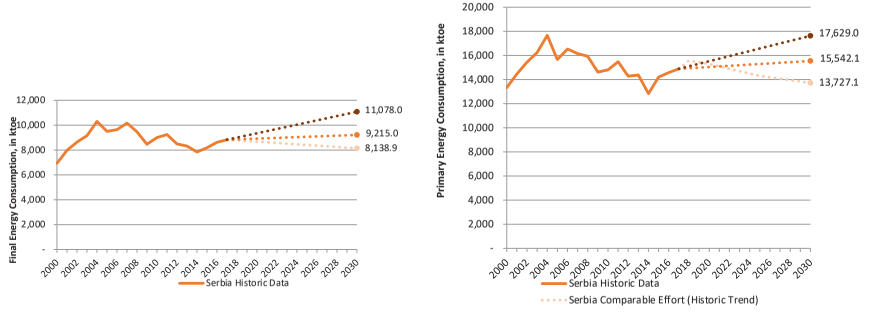


## 2. Zahtevi za energetskom transformacijom Srbije




Predloženi ciljevi Sekretarijata EnZ za oblast OIE za 2030 (Izvor: Study on 2030 overall targets (energy efficiency, RES, GHG emissions reduction) for the Energy Community, 2019)

## 2. Zahtevi za energetskom transformacijom Srbije

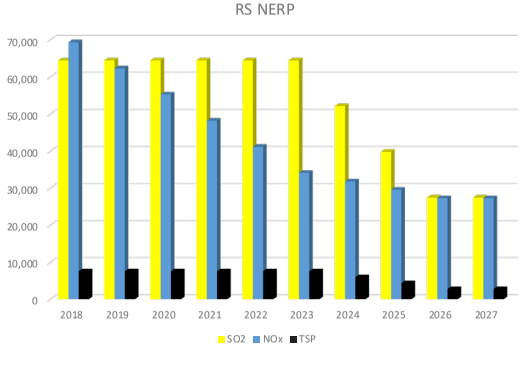



Predloženi ciljevi Sekretarijata EnZ za oblast EE za 2030. (Izvor: Study on 2030 overall targets (energy efficiency, RES, GHG emissions reduction) for the Energy Community, 2019)

## 2. Zahtevi za energetskom transformacijom Srbije

Ministarski Savet EnZ usvojio je 23. 10. 2013. godine Odluku o pravilima implementacije

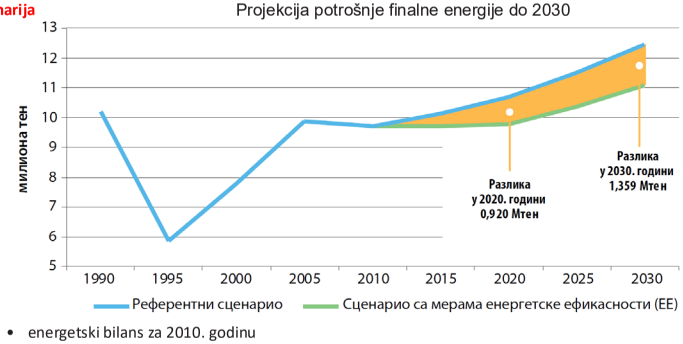
- Direktive o velikim ložištima (LCP Directive)
- Direktive o industrijskim emisijama (Directive 2010/75/EC)



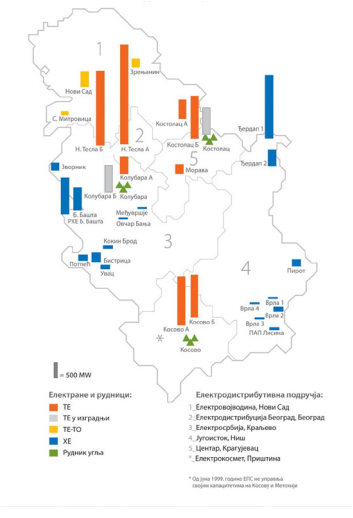

Maksimalne emisije definisane Nacionalnim planom za smanjenje emisija (NERP) iz starih velikih postrojenja za sagorevanje

## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine (iz 2015. godine)

**Dva scenarija**




- energetski bilans za 2010. godinu
- model razvoja privrede - prosečan rast privrede od 3%
- stopom fertiliteta prema - 6.8 miliona u 2030




## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**JP „Elektroprivreda Srbije“ – proizvodni kapaciteti**

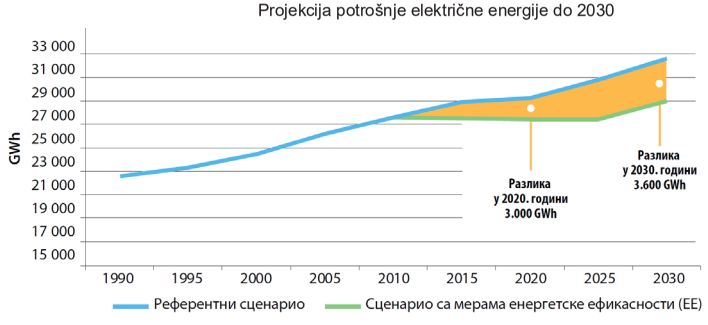
- TE Nikola Tesla A (6 blokova, 1502 MW)
- TE Nikola Tesla B (2 bloka, 1160 MW)
- TE Kolubara (5 blokova, 245 MW)
- TE Morava (sa jednim blokom, 108 MW)
- TE Kostolac A (sa 2 bloka, 281 MW)
- TE Kostolac B (sa 2 bloka, 640 MW)

- „Panonske Temoelektrane – Toplane“, 353 MW
  Zrenjanjn, Novi Sad, Sremska Mitrovica

- „Hidroelektrane Đerdap", 1328 MW
- „Vlasinske hidroelektrane” 129 MW i HE „Pirot“, 80 MW
- „Drinsko-Limske hidroelektrane“,
- „EPS Obnovljivi izvori“,

## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**Dva scenarija – SEKTOR ELEKTRIČNE ENERGIJE**




## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**SEKTOR ELEKTRIČNE ENERGIJE**

**Strateški ciljevi:**

- Obezbeđenje **sigurnog snabdevanja** domaćeg tržišta električnom energijom;
- **Razvoj tržišta električne energije** na nacionalnom i regionalnom nivou;
- **Povećanje prenosnih kapaciteta**/koridora preko Republike Srbije koji imaju regionalni i panevropski značaj;
- **Smanjenje gubitaka u distributivnim mrežama;**
- Stvaranje mogućnosti za neto izvoz električne energije.

**Prioritetne aktivnosti:**

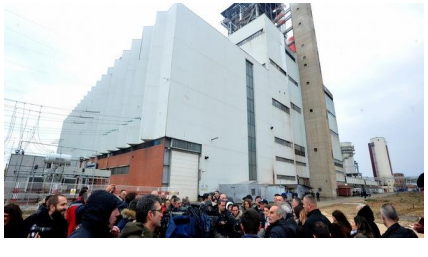
- **Rekonstrukcija termoelektrana** saglasno Direktivi o velikim ložištima;
- **Izgradnja novih termoenergetskih kapaciteta na ugalj** snage 700 MW do 2025. godine (350 MW do 2020. godine);
- **Revitalizacija HE**
- **Izgradnja RHE Bistrica**;
- **Izgradnja TE-TO na prirodni gas snage oko 450 MW** do 2020. godine;
- **Modernizacija i izgradnja** prenosne i distributivne infrastrukture.

## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

Postrojenja za **odsumporavanje** - završeni radovi na blokovi **B1 i B2 u Kostolcu**
**- započela izgradnja** u četiri bloka– **A3, A4, A5 i A6, TA Nikola Tesla A**

U toku je izgradnja **novog bloka "Kostolac B3„ -snaga 350 MW**, završetak planiran za 2020. godinu, 613 mil USD

Planira se izgradnja novi blok „**Kolubara B„ snaga 350 MW**





## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**Revitalizacija HE „Đerdap 1“**

- U toku je 5. faza revitalizacije agregata A2 HE „Đerdap 1“ - sa 176,3 MW na 190 MW (revitalizovano A1, A4, A5 i A6).
- 6. faza - agregat A3 – završetak u januaru 2021. godine







## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**Revitalizacija HE „Zvornik“ A3**

- **Završena** revitalizacija agregata **A1 i A2**
- Revitalizacija agregata **A3 počela** 11. januara 2018. godine - sa 23,2 MW na 31,4 MW
- Povećanje proizvodnje električne energije ove hidroelektrane na godišnjem nivou iznosiće i do 15%





## 3. Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine

**Hidroelektrane - projekti u fazi pripreme**

- Rehabilitacija HE „Đerdap 2“ planirani početak 2022. godine
- Rehabilitacija „Vlasinskih HE“ planirani početak 2020. godine
- Revitalizacija RHE „Bajina Bašta“
- Revitalizacija HE „Bistrica“
- Revitalizacija HE „Potpeć“



## 4. Mogući scenariji za razvoja energetskog sektora Srbije do 2050

### Kreiranje softvera za modeliranje razvoja energetskog sektora

This project is co-funded by the Republic of Serbia

**Development of Energy Planning Capacity**

EuropeAid/135625/IH/SER/RS

Contract no: 480000176//2014-28

This project is funded by the European Union

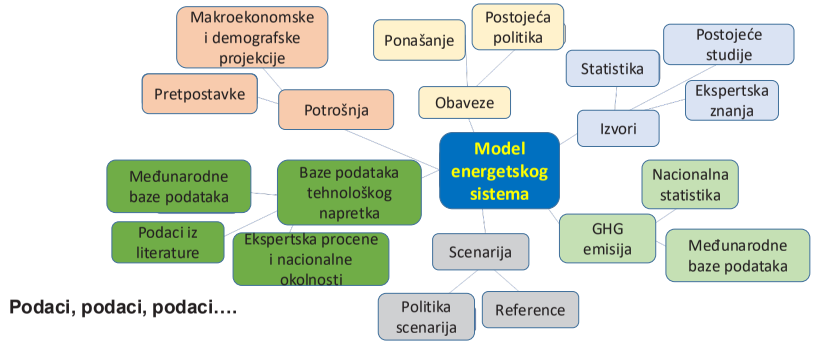
LDK Consultants Engineers and Planners SA

Center For Renewable Energy Sources

*The Development of Energy Planning Capacity Project is helping Serbia to contribute to the Europe 2020 Energy Strategy which will benefit citizens of the EU and Serbia alike, by combating climate change, increasing energy security and creating new jobs through strengthening competitiveness.*

## 4. Mogući scenariji za razvoja energetskog sektora Srbije
### Kreiranje softvera za modeliranje

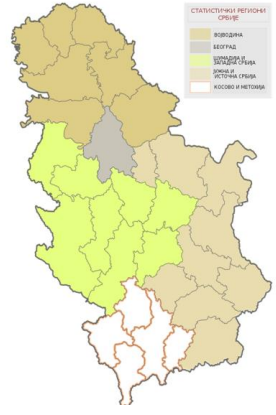
**Srpski energetski sistem za modeliranje (SEMS) razvijen je korišćenjem TIMES-ovog generatora modela**




**Podaci, podaci, podaci….**

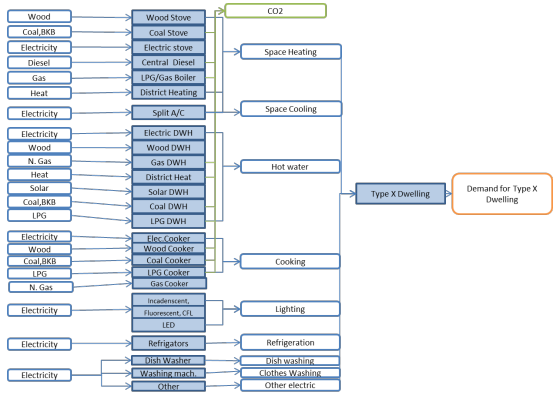
## 4. Mogući scenariji za razvoja energetskog sektora Srbije
### Kreiranje softvera za modeliranje

- Multiregionalni model (četiri regiona u Srbiji)
- Vrlo detaljan model odozdo prema gore - „bottom-up“ model
  - **Sektor električne i sektor toplotne energije predstavljen je na nivou pojedinih postrojenja**.
  - Potencijal **sopstvene proizvodnje nafte, gasa i lignita na osnovu detaljnih nacionalnih projekcija.**
  - Sektora potrošnje je raščlanjen na:
    - 34 različite tipologije objekata u stambenom sektoru
    - 7 kategorija u tercijarni sektor,
    - 13 industrijskih podsektora,
    - 13 podgrupa transporta.



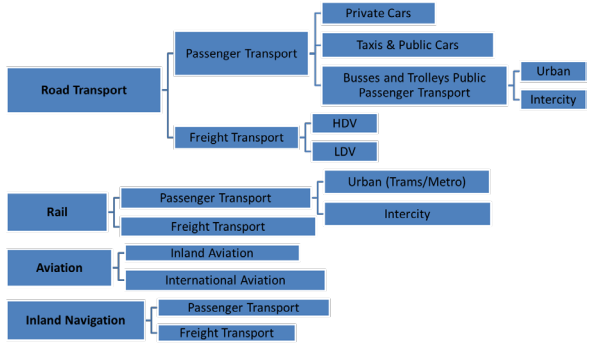
## 4. Mogući scenariji za razvoja energetskog sektora Srbije
### Razvoj softvera za modeliranje

Za svaki od 34 po tipologiji različite vrste objekata stambenog sektora je izvršena je procena potrošnje energenata, vode i emisije $CO_2$



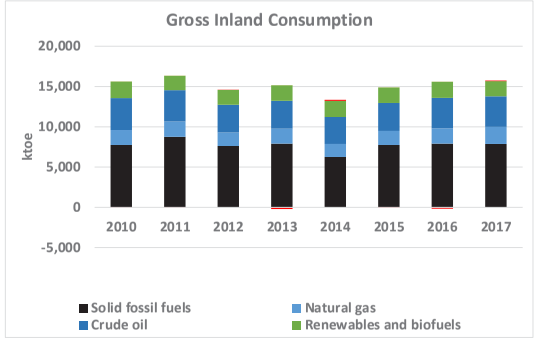

## 4. Mogući scenariji za razvoja energetskog sektora Srbije
### Razvoj softvera za modeliranje

Za 13 podgrupa transporta je izvršena je procena potrošnje energenata



## 4. Mogući scenariji za razvoja energetskog sektora Srbije
### Analiza stanja energetskog sektora Srbije

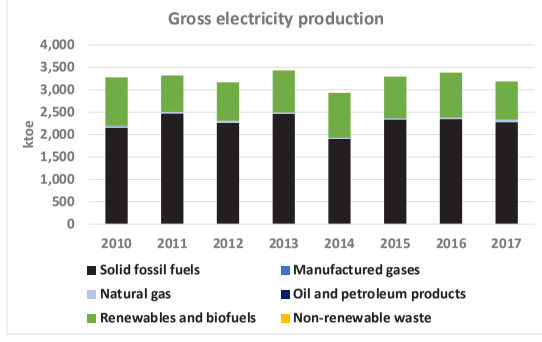
- Bruto domaća potrošnja energije u Srbiji je povećana za 1% u periodu 2010-2017
- Učešće prirodnog gasa je povećano za 14%, a čvrstih fosilnih goriva za 2%




Potrošnja primarne energije u periodu 2010-2017 (Izvor: Eurostat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Analiza stanja energetskog sektora Srbije

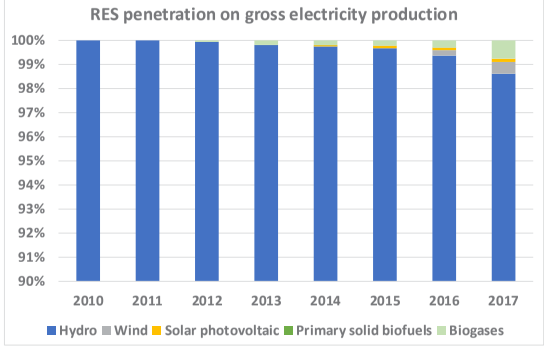
- Bruto proizvodnja električne energije smanjena je za 3% u periodu 2010-2017. Najdominantnije gorivo u proizvodnji električne energije je čvrsto fosilno gorivo, uglavnom lignit, sa povećanjem udela od 66% u 2010. godini na 71% u 2017. godini.
- Udeo OIE za proizvodnju električne energije (uključujući hidroenergiju) smanjen je sa 33% u 2010. godini na 27% u 2017. godini




Bruto proizvodnja električne energije u periodu 2010-2017 (Izvor: EuroStat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Analiza stanja energetskog sektora Srbije

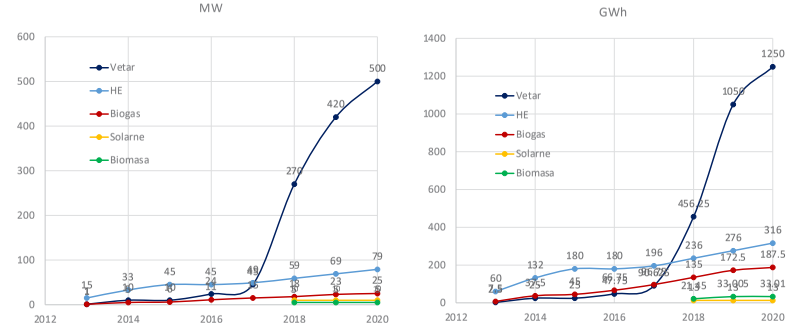
- Hidroenergija predstavlja najznačajniji obnovljivi izvor energije uprkos značajnom smanjenju proizvodnje električne energije, koja je u periodu 2010-2017. godine iznosila 22%.
- Ipak, ostale vrste OIE prikazuju značajne rastuće tendencije tokom poslednjih godina.




Udeli pojedinih OIE u bruto proizvodnji električne energije u periodu 2010-2017 (Izvor: EuroStat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Analiza stanja energetskog sektora Srbije

**EXPECTED PRODUCTION OF ELECTRICITY FROM NEW RES IN SERBIA**

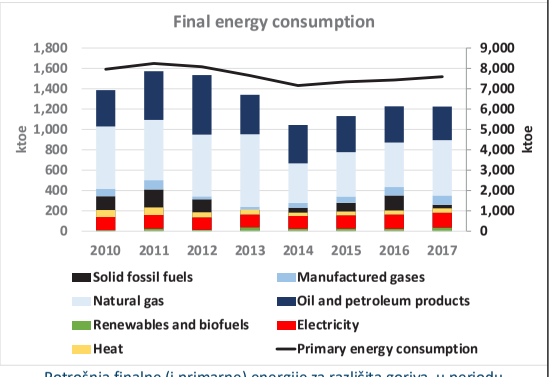



Očekivana proizvodnja električne energije iz OIE

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

### Analiza stanja energetskog sektora Srbije

- **Potrošnja finalne energije je smanjena za 4%** u periodu 2010-2017.
- **Rastući trend zabeležen u periodu od 2015. do 2017. godine**
- **Učešće nafte i naftnih derivata i električne energije je gotovo jednako** i 2017. godine je iznosilo 31%, odnosno 29%, dok je potrošnja čvrstih fosilnih goriva, prirodnog gasa i OIE manja i kreće se u rasponu od 6%-12%.

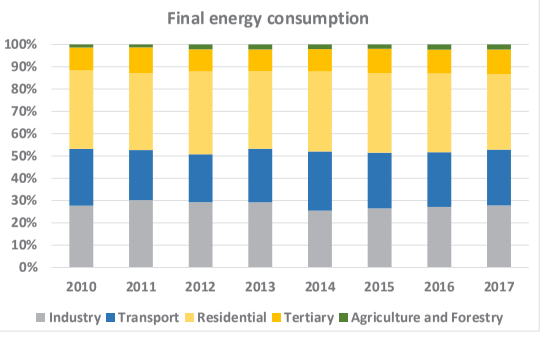



Potrošnja finalne (i primarne) energije za različita goriva u periodu 2010-2017 (Izvor: Eurostat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

### Analiza stanja energetskog sektora Srbije

- **U periodu 2010-2017, zabeleženo je smanjenje finalne potrošnje energije u stambenom sektoru za 7%, industrijskom za 3% i saobraćajnom sektoru za 6%.**

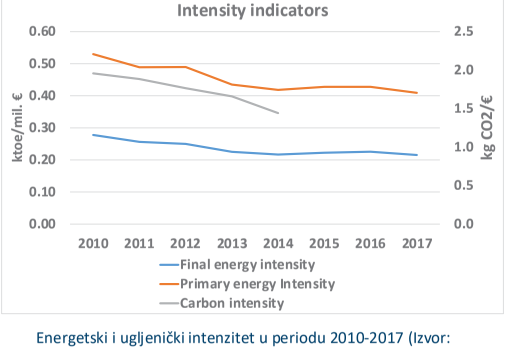



Potrošnja finalne energije za različite sektore u periodu 2010-2017 (Izvor: Eurostat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

### Analiza stanja energetskog sektora Srbije

- **Intenzitet finalne i primarne energetske potrošnje poboljšan** je u periodu 2010-2017 (smanjenje od 22%, odnosno 23%), što uglavnom predstavlja rezultat sprovedenih mera energetske efikasnosti.
- Pored toga, **ugljenički intenzitet je takođe poboljšan za 26%** u periodu 2010-2014.
- Kao rezultat povećanog učešća OIE i intervencija energetske efikasnosti. **Smanjenje emisija sa efektom staklene bašte iznosilo je 17% u periodu 2010-2014. dencijom daljeg pada**.

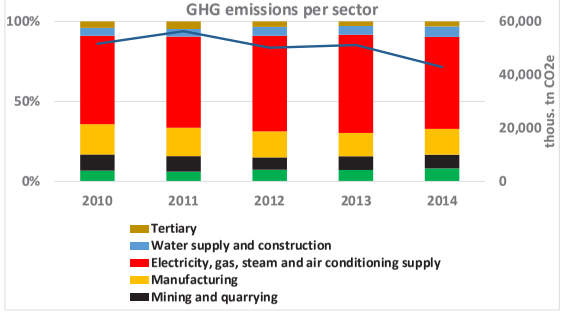



Energetski i ugljenički intenzitet u periodu 2010-2017 (Izvor: Eurostat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

### Analiza stanja energetskog sektora Srbije

- Elektroenergetski sektor, koji ima najveći doprinos (udeo od 57% u ukupnim emisijama gasova sa efektom staklene bašte u 2017), **smanjio je emisije za 14%** u periodu 2010-2014.
- **Rudarstvo i kamenolomi smanjili su emisije GHG za 30%,** proizvodnja za 29% i tercijarni sektori sa 36 %, odnosno doprineli su sa 9%, 16% i 3% emisijama GHG u 2017. godini.




Emisije GHG u periodu 2010-2017 (Izvor: Evrostat (Izvor: Eurostat, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori

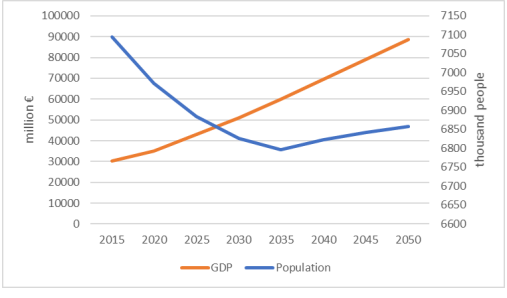
**Faktori koji se bave budućom neizvesnošću**, kao što su
- **Projekcije BDP-a** - sa 3,11% prosečna godišnja stope rasta od 2016. godine do 2050.
- **Projekcije stanovništva** - prema RZS-u sa prosečnom godišnjom stopom rasta od -0,10% od 2016. do 2050 (6,86 miliona ljudi do 2050)
- **potencijal obnovljive energije**

**Faktori koji se odnose na odluke u domenu politika**, kao što su
- primena sistema trgovanja emisijama,
- mere dekarbonizacije,
- kontrola zavisnosti od uvoza,
- uvođenje tehnologija s niskom prihvatljivošću i
- mere energetske efikasnosti

- **„Nesigurne tehnologije"** - CCS u elektranama
- **„Tehnologije sa niskom prihvatljivošću"**- tehnologije nuklearne energije

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori

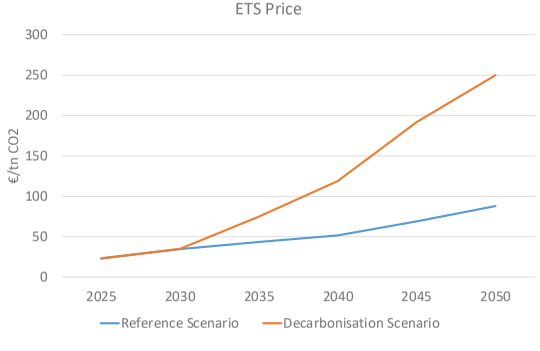
- **Projekcije BDP-a** - sa 3,11% prosečna godišnja stope rasta od 2016. godine do 2050.
- **Projekcije stanovništva** - prema RZS-u sa prosečnom godišnjom stopom rasta od -0,10% od 2016. do 2050 (6,86 miliona ljudi do 2050)




| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | Prosečna godišnja stopa rasta |
|---|---|---|---|---|---|---|---|---|---|
| Stanovništvo (000) | 7095 | 6972 | 6884 | 6826 | 6796 | 6822 | 6842 | 6858 | -0.10% |
| BDP (mil. evra) | 30312 | 35134 | 42916 | 51133 | 60014 | 69387 | 79021 | 88641 | 3.11% |

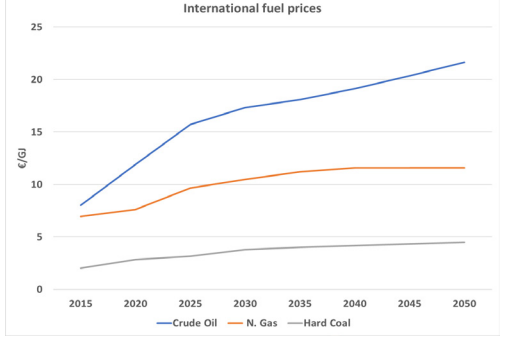
Kretanje BDP-a i stanovništva do 2050. godine (Izvor: GEM-E3 (EU) i RZS 2019).

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori



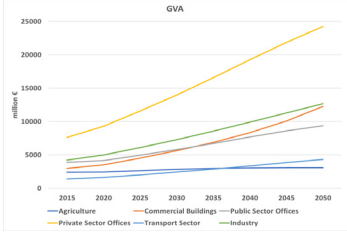

Razvoj cena ETS do 2050 (Izvor: Preporuke iz Uredbe o mehanizmima za praćenje i izveštavanje iz avgusta 2018. godine ).

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori

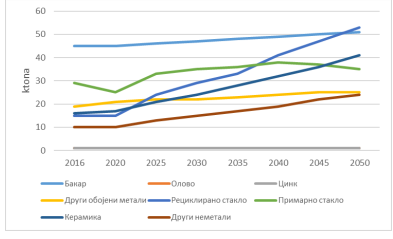



Razvoj međunarodnih cena goriva do 2050 (Izvor: Preporuke iz Uredbe o mehanizmima za praćenje i izveštavanje iz avgusta 2018. godine ).

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori

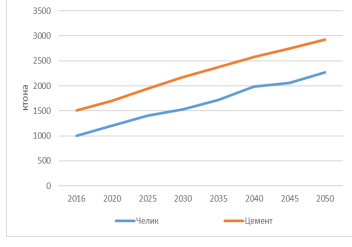



Kretanje bruto dodata vrednost za različite sektore ekonomskih aktivnosti do 2050. godine (Izvor: GEM-E3, 2019)

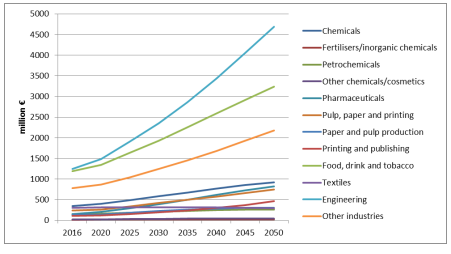



Kretanje fizičkih proizvoda energetski intenzivnih industrijskih podsektora do 2050. godine -1 (Izvor: GEM-E3, 2019).

## 3. Mogući scenariji za razvoja energetskog sektora Srbije
### Razmatrani uticajni faktori




Kretanje fizičkih proizvoda energetski intenzivnih industrijskih podsektora do 2050. godine -2 (Izvor: GEM-E3, 2019).




Kretanje bruto dodata vrednost drugih industrijskih podsektora do 2050. godine (Izvor: GEM-E3, 2019)

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

**REFERENTNI SCENARIO -** scenario nepromenjene energetske politike

1. **BDP** - 3,11% prosečne godišnje stope rasta od 2016. godine do 2050
2. **Stanovništvo** - od -0,10% od 2016. do 2050 (6,86 miliona ljudi do 2050)
3. **Ne primenjuje se ETS**
4. **Potencijal OIE** - do 2050: **2.1 GW vetar, 1 GW solarna**, 0.15 GW biogas CHP, 50 MW CHP na biomasu, 0.373GW akumulacione HE, 2.88 GW protočne HE, 0.471GW male protočne HE, 1.3 Mtoe šumske biomase, 0.7 Mtoe biomase iz poljoprivrednog otpada, 0.2Mtoe komunalnog otpada
5. **Unapređenje energetske efikasnosti**
   - **Nema raspoloživih unapređenih i naprednih tehnologija u sektorima potražnje**
   - **Ne postoje opcije za adaptaciju zgrada**
6. **Ograničenje $CO_2$** - Smanjenje od 9,8 % u 2030. godini u odnosu na nivo iz 1990. godine
7. **Bez kontrole zavisnosti od uvoza**

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

**SCENARIO ODRŽIVOG RAZVOJA-** razvoj energetskog sistema u okviru politika koje su usklađene postojećim politikama EU u pogledu energije i životne sredine

3. **ETS** - **primenjuje nakon 2025. godine, i to predstavlja glavni faktor podsticaja za uvođenje obnovljive energije za proizvodnju električne energije**
4. **OIE** - do 2050: **4 GW vetroelektrana, 3 GW solarnih**, 0.15 GW biogas CHP, 50 MW CHP na biomasu, 0.373 GW akumulacione HE, 2.88 GW protočne HE, 0.471GW male protočne HE, 1.3 Mtoe šumske biomase, 0.7 Mtoe biomase iz poljoprivrednog otpada, 0.2Mtoe komunalnog otpada
5. **Unapređenje energetske efikasnosti**
   - **Poboljšane i napredne tehnologije su dostupne za uvođenje na strani potražnje za sve namene**
   - **Maksimalna stopa adaptacija za građevinski sektor je ograničena na 1% postojećeg (neadaptiranog) inventara na godišnjem nivou**
6. **Ograničenje CO2** - Smanjenje od 9,8 % u 2030. godini u odnosu na nivo iz 1990. godine
7. **Bez kontrole zavisnosti od uvoza**

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

ZELENI SCENARIO - razvoj energetskog sistema uz intenzivniju politiku u pogledu zaštite životne sredine

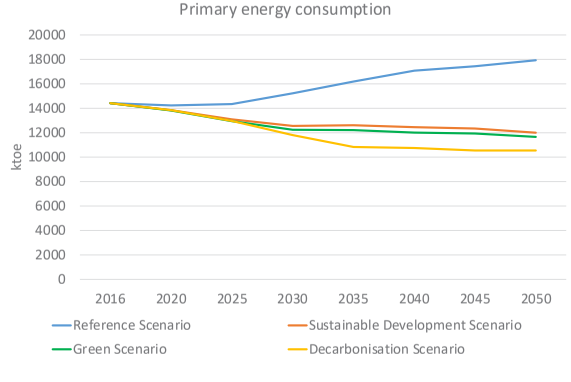
3. **ETS** - primenjuje nakon 2025. godine, koristeći visoke $CO_2$ cene, **koje se primenjuju samo u ETS sektoru**, a u skladu sa Referentnim scenarijom EU iz 2016. godine, koji predlaže Evropska komisija za Nacionalne energetske i klimatske planove
4. **OIE** - do 2050: **4 GW vetroelektrana, 3 GW solarnih**, 0.15 GW biogas CHP, 50 MW CHP na biomasu, 0.373GW akumulacione HE, 2.88 GW protočne HE, 0.471GW male protočne HE, 1.3 Mtoe šumske biomase, 0.7 Mtoe biomase iz poljoprivrednog otpada, 0.2Mtoe komunalnog otpada
5. **Unapređenje energetske efikasnosti**
   - **Sve poboljšane i napredne tehnologije su dostupne za uvođenje na strani potražnje za sve namene**
   - **Maksimalna stopa adaptacija za građevinski sektor je ograničena na 5 % postojećeg (neadaptiranog) inventara na godišnjem nivou**
6. **Ograničenje CO2** - Smanjenje od 9,8 % u 2030. godini u odnosu na nivo iz 1990. godine
7. **Bez kontrole zavisnosti od uvoza**

## 3. Mogući scenariji za razvoja energetskog sektora Srbije

SCENARIO DEKARBONIZACIJE - koristi za istraživanje stepena reagovanja energetskog sistema u Srbiji na veoma visoke podsticaje za dekarbonizaciju i namenjen je za predstavljanje ekstremne granice

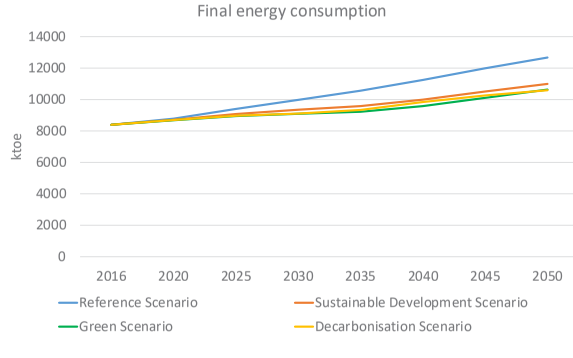
3. **ETS** - primenjuje nakon 2025. godine, koristeći visoke $CO_2$ **primenjuju na emisije iz svih sektora**
4. **OIE** do 2050: **4 GW vetroelektrana, 3 GW solarnih**, 0.15 GW biogas CHP, 50 MW CHP na biomasu, 0.373GW akumulaciona HE, 2.88 GW protočna HE, 0.471 GW mala protočna HE, 1.3 Mten šumske biomase, 0.7 Mten biomase iz poljoprivrednog otpada, 0.2Mten komunalnog otpada
5. **Unapređenje EE**
   - **Sve poboljšane i napredne tehnologije su dostupne za uvođenje na strani potražnje za sve namene**
   - **Maksimalna stopa adaptacija za građevinski sektor je ograničena na 5 % postojećeg (neadaptiranog) inventara na godišnjem nivou**
6. **Ograničenje CO2** - Smanjenje od 9,8 % u 2030. godini u odnosu na nivo iz 1990. godine
7. **Bez kontrole zavisnosti od uvoza**

## 4. Rezultati proračuna



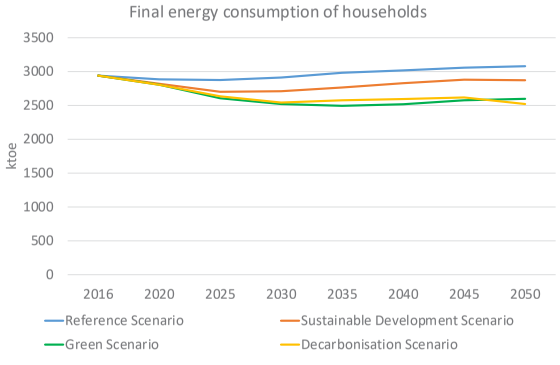

Potrošnja primarne energije

## 4. Rezultati proračuna



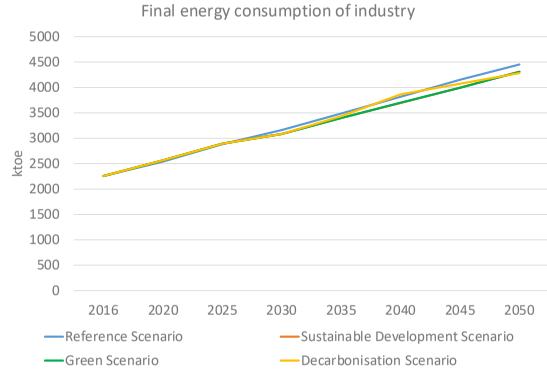

Potrošnja finalne energije

## 4. Rezultati proračuna



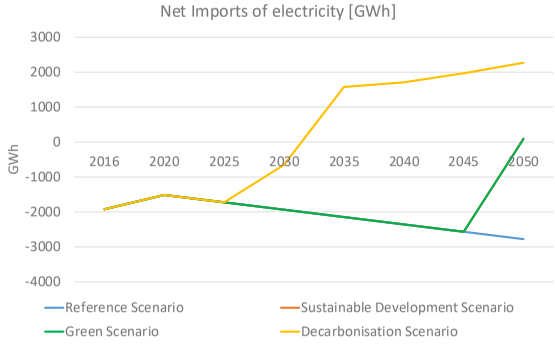

Finalna potrošnja energije u domaćinstvima

## 4. Rezultati proračuna



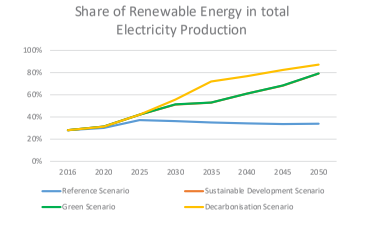

Finalna potrošnja energije u industriji

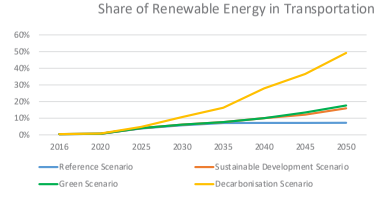
## 4. Rezultati proračuna

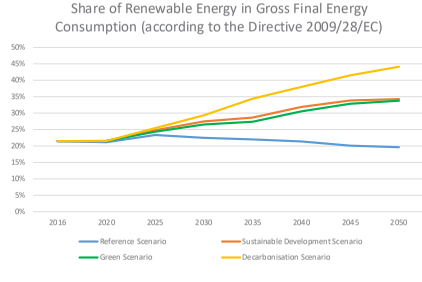



Uvoz električne energije

## 4. Rezultati proračuna

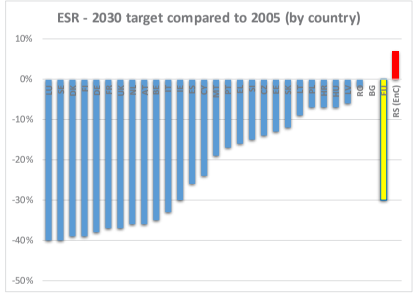


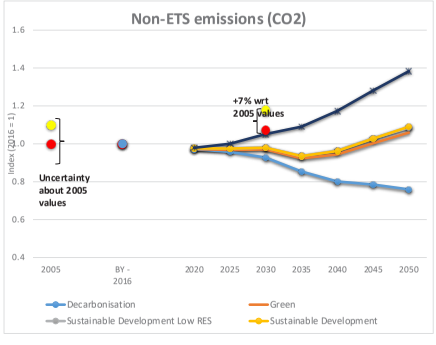




Udeo OIE u proizvodnji električne energije, transportu i potrošnji finalne energije

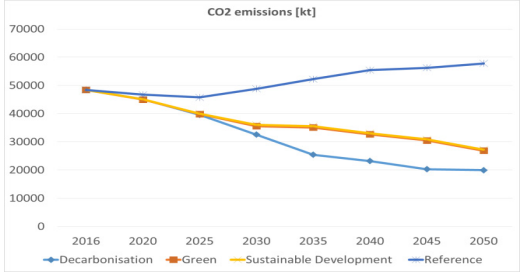
## 5. Zaključci



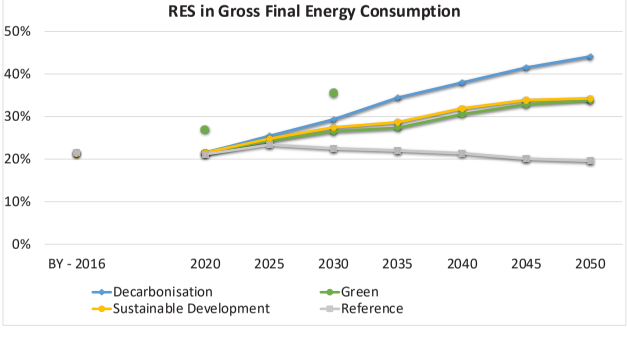

Ciljevi Uredbe za emisije koje nisu obuhvaćene sa ETS (domaćinstva, zgrade, saobraćaj, poljoprivreda, usluge i manje industrije) i poređenje projekcijama emisija za različite scenarije

## 5. Zaključci



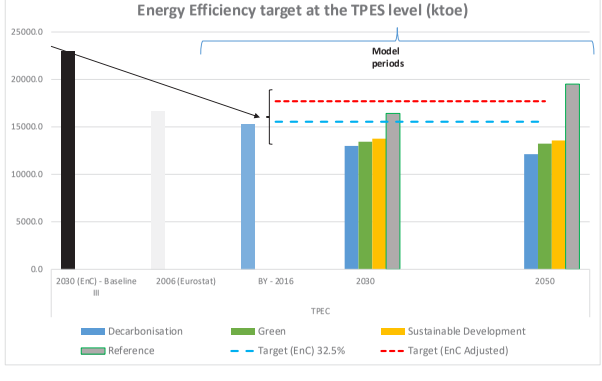

- Svi razmatrani scenariji, osim Referentnog bez ETS, pokazuju da energetski sistem Srbije ima značajan potencijal za dekarbonizaciju.
- Energetski sektor je prvi koji će reagovati u slučaju implementacije ETS, kako bi se prilagodio višim troškovima proizvodnje električne energije.

## 5. Zaključci



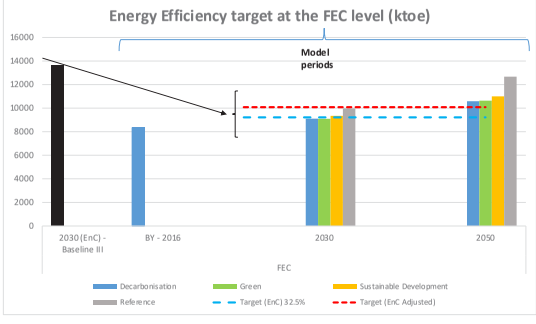

- Obnovljiva energija može odigrati glavnu ulogu u dekarbonizaciji energetskog sistema Srbije, mada udeo OIE u bruto finalnoj potrošnji energije ne može tako lako da dostigne ciljeve koji su razmatrani za 2020. godinu u važećoj Energetskoj strategiji i koje je predložila Energetska zajednica za 2030. godinu.

## 5. Zaključci




Opšti zaključak za rezultate scenarija je da se ciljevi za 2030. mogu ostvariti kako za **ukupnu primarnu** potrošnju energije, tako i za finalnu potrošnju energije.

## 5. Zaključci

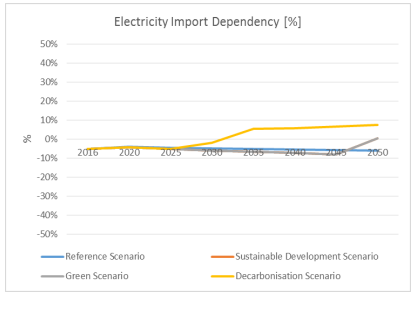


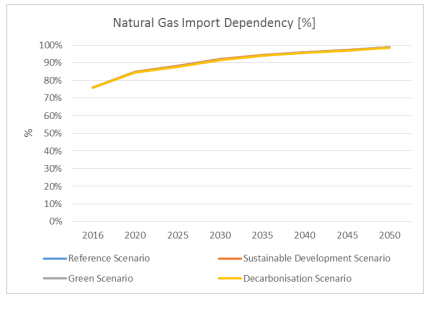

Međutim, u periodu do 2050. godine više pažnje treba posvetiti sektorima potražnje kako bi se stabilizovao ili čak još više smanjio nivo **potrošnje finalne energije**. Sadašnja kombinacija mera pokazuje da će se ukupna primarna potrošnja energije stabilizovati nakon 2030. godine.

## 5. Zaključci

| 2030 | | | | | |
|---|---|---|---|---|---|
| **Naziv scenarija** | **FPE (kten)** | **Emisije $CO_2$ koje nisu obuhvaćene sa ETS (kt)** | **% povećanje $CO_2$ iz sektora koji nisu obuhvaćeni sa ETS u odnosu na 2005.** | **Ukupne ekvivalentne emisije $CO_2$ (kt)** | **Smanjenje emisije $CO_2$ u odnosu na 2005.** |
| Referentni scenario | 9980 | 11373 | -46% | 49423 | -21% |
| Scenario održivog razvoja | 9349 | 10607 | -50% | 36650 | -41% |
| Zeleni scenario sa visokim cenama ETS | 9116 | 10468 | -51% | 36001 | -42% |
| Scenario dekarbonizacije | 9107 | 10089 | -52% | 33194 | -47% |
| **2050** | | | | | |
| **Naziv scenarija** | **FPE (kten)** | **Emisije $CO_2$ koje nisu obuhvaćene sa ETS (kt)** | **% povećanje $CO_2$ iz sektora koji nisu obuhvaćeni sa ETS u odnosu na 2005.** | **Ukupne ekvivalentne emisije $CO_2$ (kt)** | **Smanjenje emisije $CO_2$ u odnosu na 2005.** |
| Referentni scenario | 12676 | 14856 | -30% | 58502 | -6% |
| Scenario održivog razvoja | 10997 | 11834 | -44% | 27970 | -55% |
| Zeleni scenario sa visokim cenama ETS | 10598 | 11547 | -45% | 23253 | -63% |
| Scenario dekarbonizacije | 10589 | 8807 | -58% | 20992 | -66% |

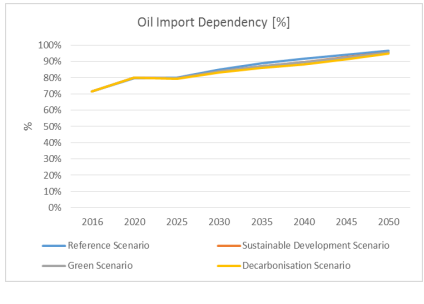
## 5. Zaključci

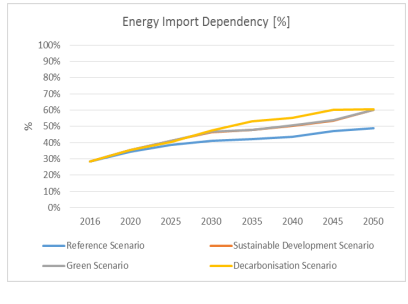



Zavisnost od uvoza energije može se smatrati prvim indikatorom energetske sigurnosti. Sveukupna tendencija koja se primećuje u svim scenarijima je povećanje ukupne zavisnosti od uvoza energije i zavisnosti od uvoza prirodnog gasa i nafte, što je očekivano zbog postepenog smanjenja domaćih resursa

## 5. Zaključci



**Gligor Kanevče**
**Macedonian Academy of Sciences and Arts,**
**Research Center for Energy and Sustainable Development**

# The future of thermal power plants - challenges and opportunities for energy development in Macedonia

Sarajevo, November 21, 2019

**Macedonian Academy of Sciences and Arts,**
**Research Center for Energy and Sustainable Development**

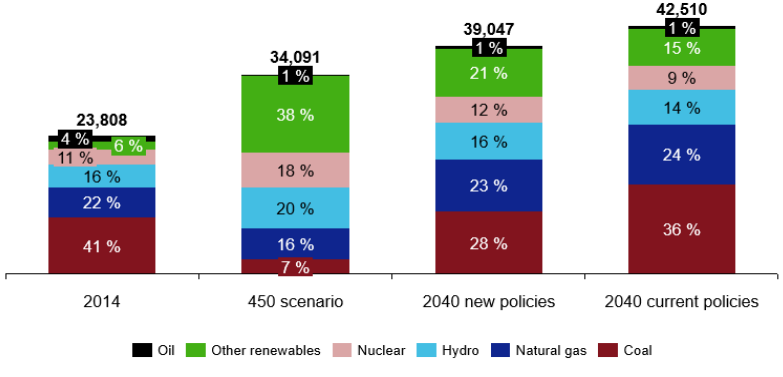
***The Strategy for Energy Development of the Republic of Macedonia until 2040***

UK Government,
PricewaterhouseCoopers (PwC)

***Macedonia's Fourth National Communication and Third Biennial Update Report on Climate Change under the UNFCCC***

UNDP

**World energy generation by source, 2014 – 2040, TWh**

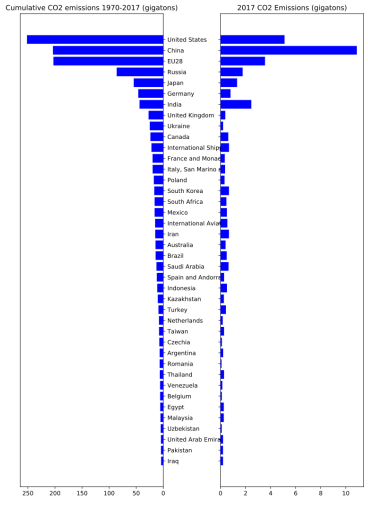


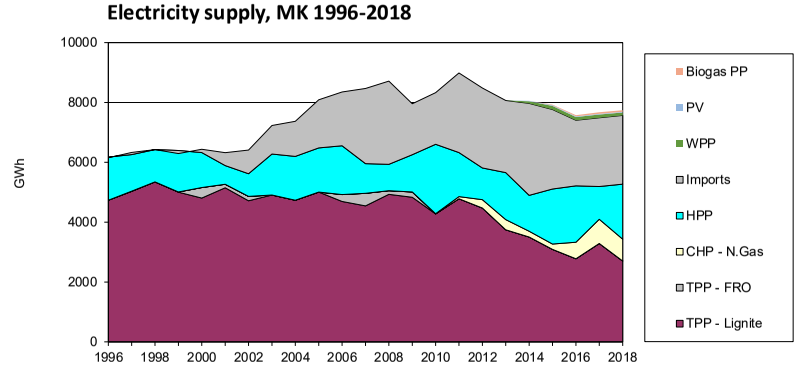

*Извор: IEA World Energy Outlook*

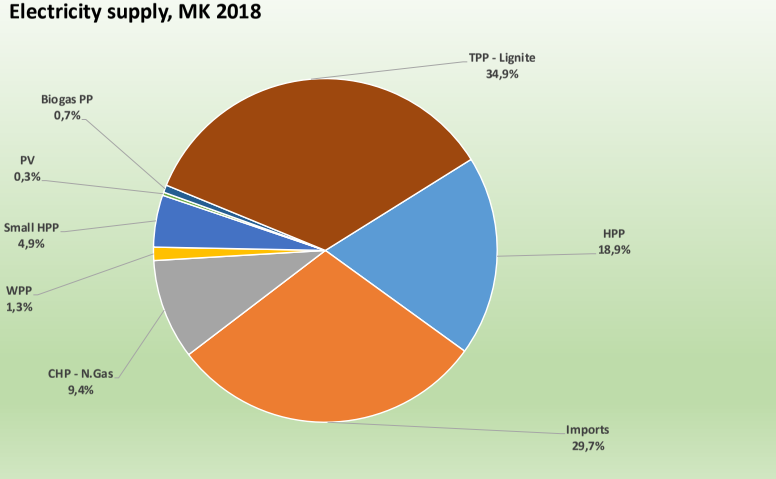
**The Paris Agreement**, December 2015
**To this date, 187 Parties have ratified** of 197 Parties to the Convention

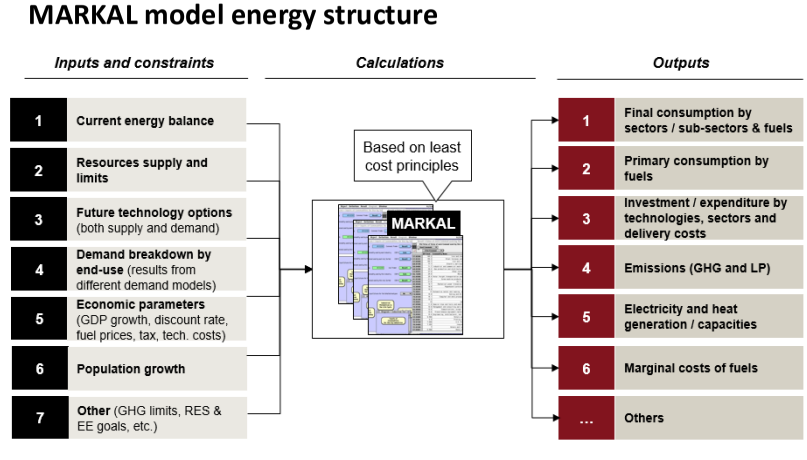
**Essential elements:**

- Keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius;
- Enhanced transparency of action and support through a more robust transparency framework;
- Appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

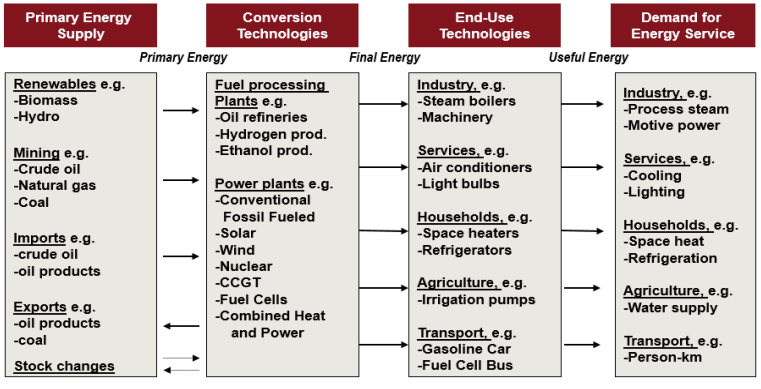

Cumulative CO2 emissions 1970-2017 (gigatons)
2017 CO2 Emissions (gigatons)
United States
China
EU28
Russia
Japan
Germany
India
United Kingdom
Ukraine
Canada
International Ship
France and Monac
Italy, San Marino
Poland
South Korea
South Africa
Mexico
International Avia
Iran
Australia
Brazil
Saudi Arabia
Spain and Andorra
Indonesia
Kazakhstan
Turkey
Netherlands
Taiwan
Czechia
Argentina
Romania
Thailand
Venezuela
Belgium
Egypt
Malaysia
Uzbekistan
United Arab Emira
Pakistan
Iraq
250 200 150 100 50 0
0 2 4 6 8 10


Electricity supply, MK 1996-2018
GWh
10000
8000
6000
4000
2000
0
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
Biogas PP
PV
WPP
Imports
HPP
CHP - N.Gas
TPP - FRO
TPP - Lignite

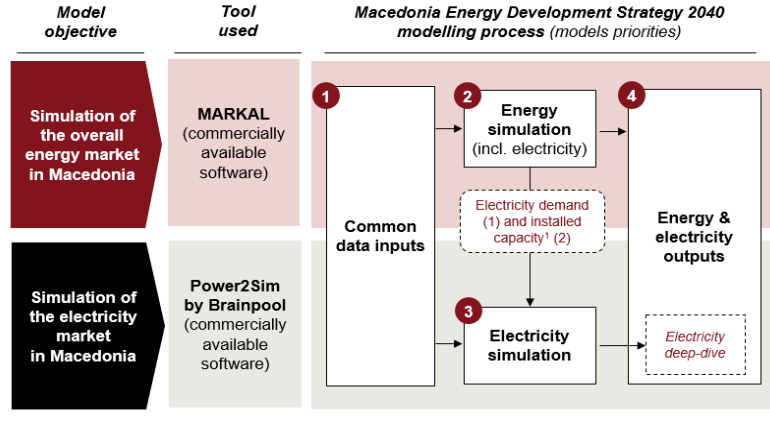

Electricity supply, MK 2018
TPP - Lignite
34,9%
Biogas PP
0,7%
PV
0,3%
Small HPP
4,9%
WPP
1,3%
CHP - N.Gas
9,4%
HPP
18,9%
Imports
29,7%


MARKAL model energy structure
Inputs and constraints
Calculations
Outputs
1 Current energy balance
2 Resources supply and limits
3 Future technology options (both supply and demand)
4 Demand breakdown by end-use (results from different demand models)
5 Economic parameters (GDP growth, discount rate, fuel prices, tax, tech. costs)
6 Population growth
7 Other (GHG limits, RES & EE goals, etc.)
Based on least cost principles
MARKAL
1 Final consumption by sectors / sub-sectors & fuels
2 Primary consumption by fuels
3 Investment / expenditure by technologies, sectors and delivery costs
4 Emissions (GHG and LP)
5 Electricity and heat generation / capacities
6 Marginal costs of fuels
... Others

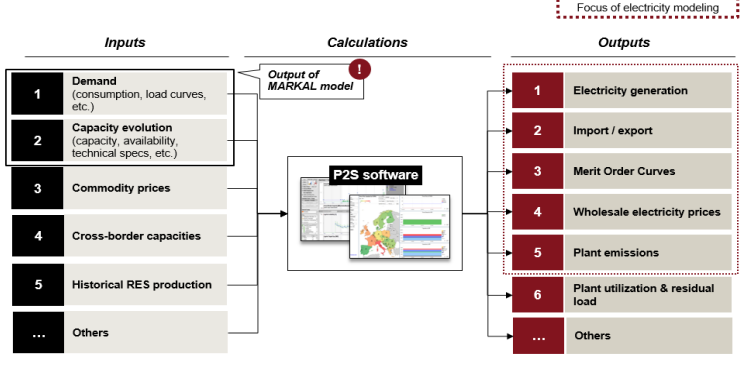
## MARKAL model key components




## Modelling framework




## Electricity model (P2S) structure




## Overview of scenarios for the development of Macedonian energy system until 2040

***Reference scenario***

- Current energy policies
- ETS entrance – 2027
- Commodity prices - Current policies scenario (WEO 2017)

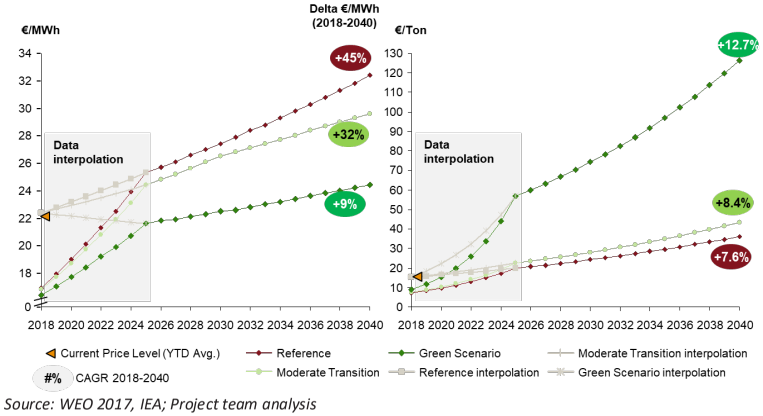
***Moderate Transition scenario***

- Progressive policies – RES and EE
- ETS entrance – 2025
- Commodity prices – New policy scenario (WEO 2017)

***Green scenario***

- Radical transition from conventional to new policy – RES and EE
- ETS entrance – 2023
- Commodity prices – Sustainable development scenario (WEO 2017)

Gas price projection, 2018 – 2040

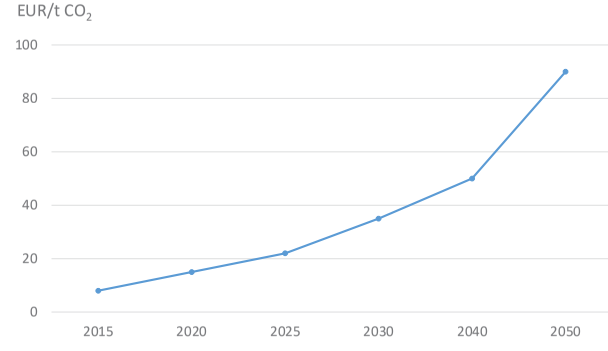



$CO_2$ price projections, 2018 - 2040



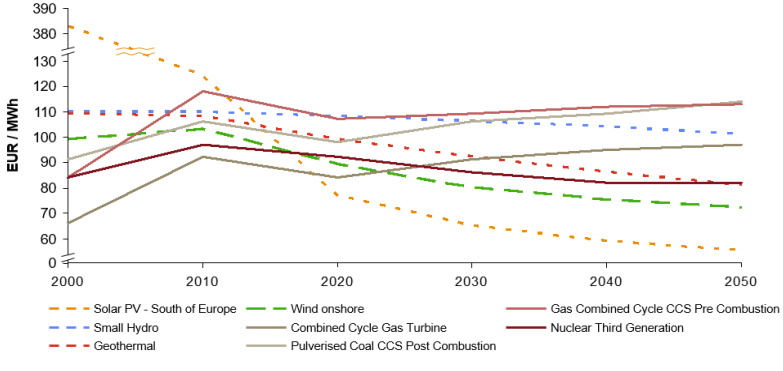

*Source: WEO 2017, IEA; Project team analysis*

$CO_2$ price projections, 2015 – 2050



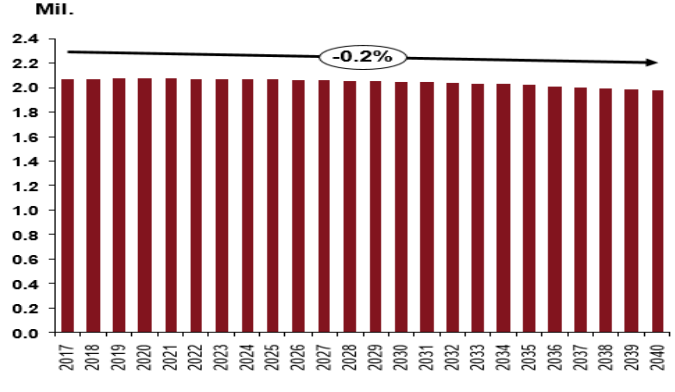

*Izvor: Referentno scenario EU 2016*

## Levelized costs for electricity generation technologies, 2000 – 2050



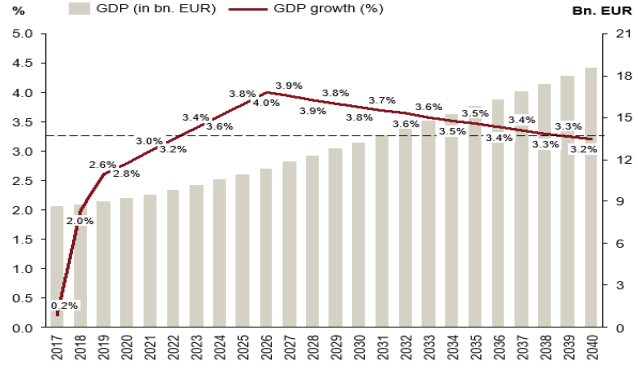

*Source: EU Reference Scenario 2016, Project team analysis*

## Macedonia population growth



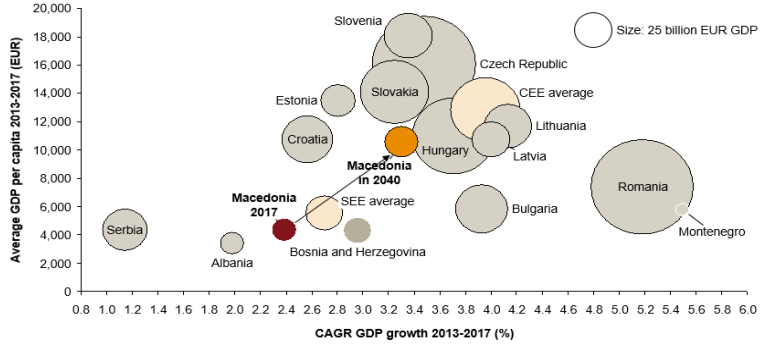

*Source: State Statistical Office, UN*

## Macedonia GDP projections

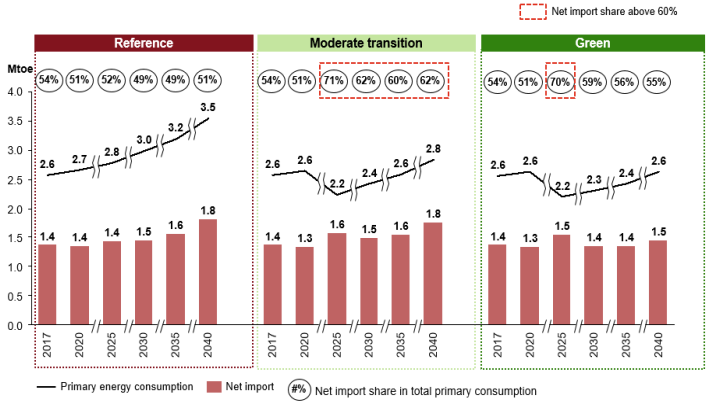



*Source: IMF + Project team estimations after 2024*

## CEE and SEE GDP trends




## Total primary consumption and net import share in total primary consumption



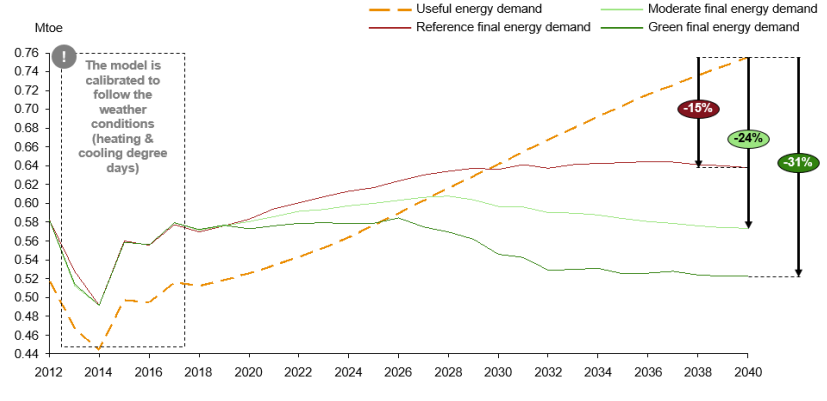

**AGR**

**RS**
TPC 1.4 %
NI 1.1 %

**MTS**
TPC 0.5 %
NI 1.1 %

**GS**
TPC 0.1 %
NI 0.3 %

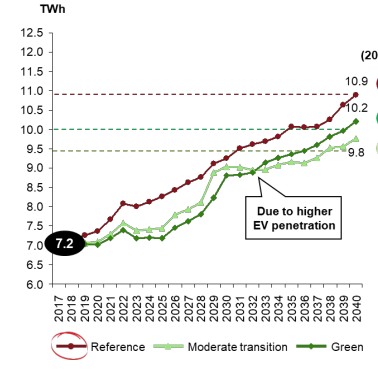
## Useful vs. final energy consumption in household sector, by scenario



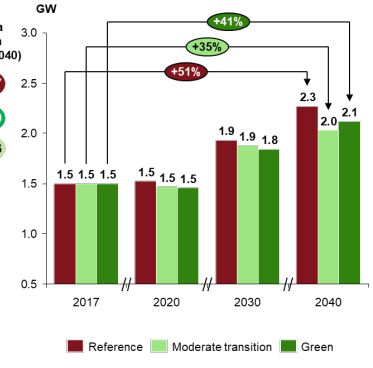
## Macedonia electricity market evolution in a nutshell

| Focus | Today (2017) | 2040 Reference | 2040 Moderate Transition | 2040 Green |
|---|---|---|---|---|
| Demand | Demand 1.5 GW<br>Consumption 7.2 TWh | Demand 2.3 GW (+ 51%)<br>Consumption 10.9 TWh | Demand 2.0 GW (+ 35%)<br>Consumption 9.8 TWh | Demand 2.1 GW (+ 41%)<br>Consumption 10.2 TWh |
| Supply | RES production @ 25%<br>(mostly hydro reservoir) | RES production @ 71%<br>(45% Hydro) | RES production @ 78%<br>(44% Hydro) | RES production @ 90%<br>(49% Hydro) |
| Supply & Demand balance | Negative net import balance @ 27%<br>and theoretical reserve margin @ +7% | Negative net import balance @ 14%<br>and negative theoretical reserve margin @ -8% | Negative net import balance @ 8%<br>and negative theoretical reserve margin @ -4% | Negative net import balance @ 12%<br>and negative theoretical reserve margin @ -23% |
| Wholesale electricity prices | 48 €/MWh | 66 €/MWh<br>(+38% vs. +91% avg. commodity prices[1]) | 63 €/MWh<br>(+31% vs. +109% avg. commodity prices[1]) | 72 €/MWh<br>(+50% vs. +370% avg. commodity prices[1]) |
| Emissions | 4.4 Mt CO2<br>54 k tons of local pollutants | 2.5 Mt CO2 (-42% vs. '17) and 9 k tons local pollutants (-83% vs. '17) | 0.7 Mt CO2 (-84% vs. '17) and 0.7 k tons local pollutants (-99% vs. '17) | 0.3 Mt CO2 (-93% vs. '17) and 0.4 k tons local pollutants (-99% vs. '17) |

## Electricity consumption evolution




## Electricity peak demand




## Macedonia electricity market evolution in a nutshell

| Focus | Today (2017) | 2040 Reference | 2040 Moderate Transition | 2040 Green |
|---|---|---|---|---|
| Demand | Demand 1.5 GW<br>Consumption 7.2 TWh | Demand 2.3 GW (+ 51%)<br>Consumption 10.9 TWh | Demand 2.0 GW (+ 35%)<br>Consumption 9.8 TWh | Demand 2.1 GW (+ 41%)<br>Consumption 10.2 TWh |
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| Wholesale electricity prices | 48 €/MWh | 66 €/MWh<br>(+38% vs. +91% avg. commodity prices[1]) | 63 €/MWh<br>(+31% vs. +109% avg. commodity prices[1]) | 72 €/MWh<br>(+50% vs. +370% avg. commodity prices[1]) |
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## Planned generation capacity phase-outs – Reference Scenario

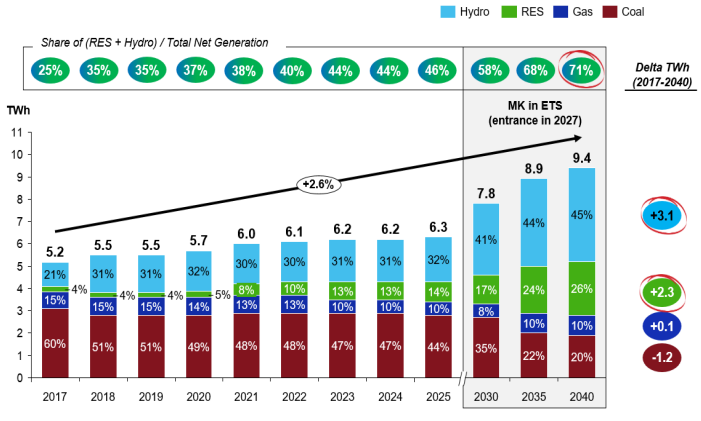
| Plant | Tech-nology | Capacity (Net, MW) | Phase-out (Year) |
|---|---|---|---|
| Oslomej | Lignite | 100 | 2019 |
| Negotino | Oil | 198 | 2020 |
| Total phased-out capacity (GW) | | 0.3 | 2019-2020 |

## Planned key generation capacity investments - RS

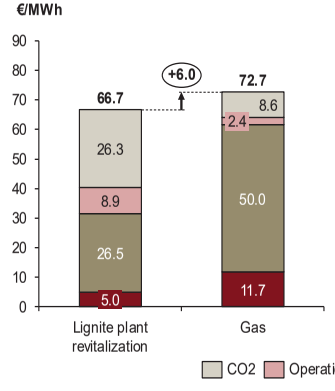
| Plant | Tech-nology | Capacity (Net, MW) | % on tot. | Entrance (Year) |
|---|---|---|---|---|
| New Wind promoted | Wind | 113 | 5% | 2018-2023 |
| New Wind non-prom. | Wind | 350 | 15% | 2031-2040 |
| New PV promoted | Solar | 457 | 20% | 2020-2040 |
| New PV non-prom. | Solar | 400 | 17% | 2028-2036 |
| New Biogas | Biogas | 23 | 1% | 2020-2040 |
| Cebren | Hydro | 123 – 458 | 20% | 2029-2037 |
| Gradec | Hydro | 75 | 3% | 2030 |
| Veles | Hydro | 96 | 4% | 2030 |
| Globocica II | Hydro | 20 | 1% | 2037 |
| Kanal Vardar – Kozjak | Hydro | 126 | 5% | 2030 |
| New Small Hydro | Hydro | 223 | 10% | 2019-2040 |
| Total new capacity (GW) | | 2.3 | 100% | 2018-2040 |

! Tables do not include plants revitalizations such as Bitola or Gas CHP plants (life extension of 260 MW from 2033)

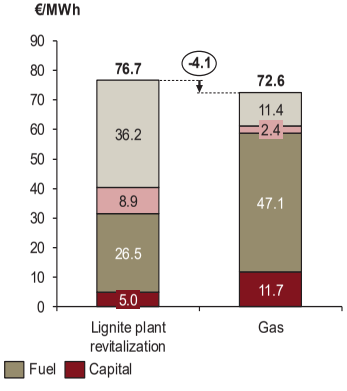
## Evolution of total net generation mix – Reference scenario, 2017 - 2040




## Impact of $CO_2$ tax on coal fired PPs – Reference scenario




## Impact of $CO_2$ tax on coal fired PPs – Moderate transition scenario




## Planned generation capacity phase-outs – Moderate Transition Scenario

| Plant | Tech-nology | Capacity (Net, MW) | Phase-out (Year) |
|---|---|---|---|
| Oslomej | Lignite | 100 | 2019 |
| Bitola | Lignite | 636 | 2025 |
| Negotino | Oil | 198 | 2020 |
| Total phased-out capacity (GW) | | 0.9 | 2019-2025 |

## Planned key generation capacity investments – MTS

| Plant | Tech-nology | Capacity (Net, MW) | % on tot. | Entrance (Year) |
|---|---|---|---|---|
| New Wind promoted | Wind | 113 | 4% | 2018-2023 |
| New Wind non-prom. | Wind | 450 | 15% | 2029-2040 |
| New PV promoted | Solar | 547 | 18% | 2025-2036 |
| New PV non-prom. | Solar | 610 | 20% | 2018-2040 |
| New Biogas | Biogas | 23 | 1% | 2020-2036 |
| New Biomass | Biomass | 15 | 0% | 2020-2035 |
| New Large Hydro (Cebren, Gradec, Veles, KV Kozjak, Globocica) | Hydro | 775 | 26% | 2029-2037 |
| New Small Hydro | Hydro | 223 | 7% | 2019-2040 |
| New Gas TPP | Gas | 85 | 3% | 2025 |
| New Gas CHP 1 | Gas | 119 | 4% | 2039 |
| New Gas CHP 2 | Gas | 61 | 2% | 2040 |
| Total new capacity (GW) | | 3.0 | 100% | 2018-2040 |

N.B. Tables do not include Gas CHP plants revitalization (life extension of 260 MW from 2033)

## Planned generation capacity phase-outs – Green Scenario

| Plant | Tech-nology | Capacity (Net, MW) | Phase-out (Year) |
|---|---|---|---|
| Oslomej | Lignite | 100 | 2019 |
| Bitola | Lignite | 636 | 2025 |
| Negotino | Oil | 198 | 2020 |
| TE-TO (CHP) | Gas | 230 | 2033 |
| Total phased-out capacity (GW) | | 1.2 | 2019-2033 |

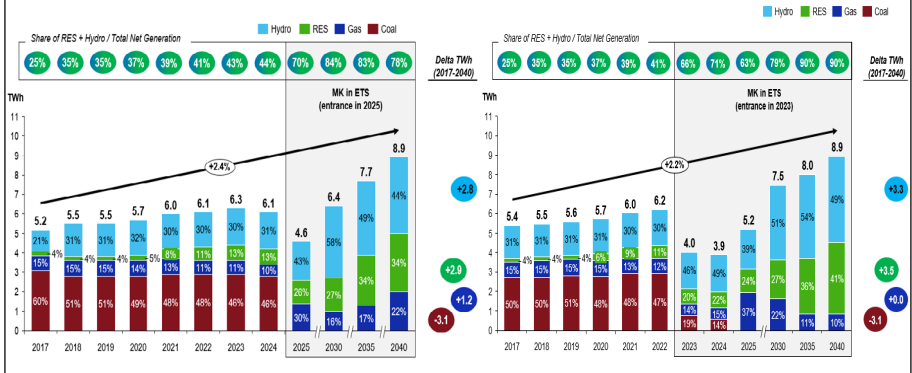
## Planned key generation capacity investments – GS

| Plant | Tech-nology | Capacity (Net, MW) | % on tot. | Entrance (Year) |
|---|---|---|---|---|
| New Wind promoted | Wind | 113 | 3.5% | 2018-2023 |
| New Wind non-prom. | Wind | 600 | 18.5% | 2029-2040 |
| New PV promoted | Solar | 597 | 18.4% | 2025-2039 |
| New PV non-prom. | Solar | 760 | 23.4% | 2018-2040 |
| New Biogas | Biogas | 23 | 0.7% | 2020-2036 |
| New Biomass | Biomass | 15 | 0.5% | 2020-2035 |
| New Large Hydro (Cebren, Gradec, Veles, KV Kozjak, Globocica) | Hydro | 775 | 23.9% | 2029-2037 |
| New Small Hydro | Hydro | 223 | 6.9% | 2019-2040 |
| New Gas TPP | Gas | 141 | 4.3% | 2025 |
| Total new capacity (GW) | | 3.2 | 100% | 2018-2040 |

N.B. Tables do not include Gas CHP plants revitalization (life extension of 70 MW from 2033)

## Evolution of total net generation mix –2017-2040

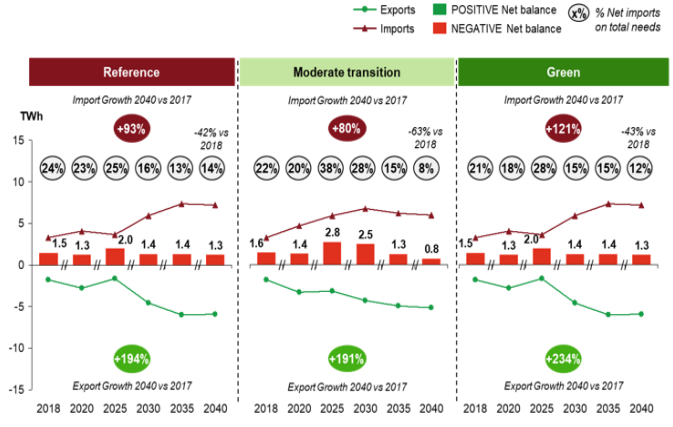
### Moderate transition scenario




### Green scenario




## Evolution of total net generation mix –2017-2040




## Opportunities for TPP Bitola

- Natural Gas TPP
- Photovoltaic systems (PV),
- New technologies development, Energy efficiency and RES Projects,
- Hydro-pumped Storage Power Plants - Cebren

*Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji*

Sarajevo, 21. novembar 2019.

# MODEL SREDNJOROČNOG RAZVOJA PROIZVODNOG PORTFOLIJA BOSNE I HERCEGOVINE DO 2035. SA PROJEKCIJOM RAZVOJA DO 2050. GODINE

## Mid-term Generation Portfolio Development Model for Bosnia and Herzegovina until 2035 with a Projection until Year 2050

**Ajla Merzić, Anes Kazagić, Mustafa Musić, Miroslav Nikolić, Zdravko Milovanović, Dušan Golubović, Petar Gvero**



## Sadržaj prezentacije

- Umjesto uvoda
- Identifikacija problema
- Konceptualizacija modela tranzicije
- Rezultati



## Umjesto uvoda



- **ČINJENICA: Negativan uticaji energetskog sektora na okolinu**

*„... izgaranje fosilnih goriva učestvuje sa oko 90% u ukupnim globalnim emisijama $CO_2$, od čega 80% uzrokuje energetski sektor..."*

Renewable Energy Policy Network for the 21st Century, Renewables - Global Futures Report 2012, Japan, 2013.

- **ČINJENICA: Sve rigorozniji zahtjevi u borbi protiv klimatskih promjena**

*„... zadržati porast globalne prosječne temperature znatno ispod 2°C u odnosu na predindustrijske razine..."*

Paris Agreement, United Nations, Framework Convention on Climate Change (UNFCCC), 2016.



## Umjesto uvoda




**U središu pozornosti:**

**SMANJENJE NEGATIVNOG UTICAJA (ELEKTRO)ENERGETSKOG SEKTORA NA OKOLIŠ**

**SMANJENJE EMISIJA POLUTANATA**

**SMANJENJE EMISIJA STAKLENIČKIH GASOVA - DEKARBONIZACIJA**

## Umjesto uvoda

**Ključne mjere:**

**LIMITIRANJE EKSPLOATACIJE FOSILNIH GORIVA**
**POVEĆANJE ENERGIJSKE EFIKASNOSTI**
**INTENZIVNA INTEGRACIJA OBNOVLJIVIH IZVORA ENERGIJE**





## Umjesto uvoda

**Ključne mjere:**

**ENERGETSKA TRANZICIJA**





## Identifikacija problema

- Bosna i Hercegovina i aktuelni status:
  - zemlja u razvoju
  - konvencionalni proizvodni portfolio:
    - instalisani kapaciteti u konvencionalnim izvorima na prijenosnoj mreži:
      TE: 1.888 MW
      HE: 2.095 MW
    - instalisani kapaciteti u nekonvencionalnim izvorima na prijenosnoj mreži:
      VE: 86.6 MW
    - proizvodni portfolio dominantno baziran na uglju (cca. 60%)
  - (neto) izvoznik električne energije
  - značajan potencijal u OIE

- Energetska tranzicija i „novi" uslovi rada:
  - smanjenje emisija
  - intenziviranje integracije proizvodnih EEO na bazi OIE
  - intermitentnost resursa, proizvodnje i izlazne snage
  - obezbjeđenje balansne snage
  - intenzivna uspostava tržišta električne energije



## Identifikacija problema

- Bosna i Hercegovina i aktuelni status:
  - zemlja u razvoju
  - konvencionalni proizvodni portfolio:
    - instalisani kapaciteti u konvencionalnim izvorima na prijenosnoj mreži:
  - (neto) izv
  - značajan

**- Identifikacija problema -**
**Prijelaz „konvencionalnog" elektroenergetskog sistema zemlje u razvoju u održiv elektroenergetski sistem u „novim" uslovima rada**
**- Elektroenergetski sistem budućnosti –**

- Energetska tranzicija i „novi" uslovi rada:
  - smanjenje emisija
  - intenziviranje integracije proizvodnih EEO na bazi OIE
  - intermitentnost resursa, proizvodnje i izlazne snage
  - obezbjeđenje balansne snage
  - intenzivna uspostava tržišta električne energije

## Konceptualizacija modela tranzicije

Polazni „konvencionalni" EES BiH

EU Direktive 20/20/20 Targets

Razvojni planovi

Strateška opredjeljenja

Međunarodni propisi

WASP IV (International Atomic Energy Agency)

HOMER

MESSAGE (International Atomic Energy Agency)

Održiv EES BiH u „novim" uslovima rada

Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji

## Konceptualizacija modela tranzicije

Polazni „konvencionalni" EES BiH

„Novi" uslovi rada:

- smanjenje emisija stakleničkih gasova najmanje za 20% u odnosu na zatečeno stanje
- integracija proizvodnih EEO na bazi OIE, 30% i više snage u vjetroelektranama u odnosu na ukupnu instalisanu snagu u polaznom modelu
- participacija hibridnih sistema sa mogućnošću skladištenja, konverzije i korištenja energije za balansiranje
- balansiranje očekivanih varijacija izlazne snage
- tržište električne energije
- zadovoljavajuća vrijednost LOLP

Održiv EES BiH u „novim" uslovima rada

Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji

## Konceptualizacija modela tranzicije

Polazni „konvencionalni" EES BiH

„Novi" uslovi rada:

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- participacija hibridnih sistema sa mogućnošću skladištenja, konverzije i korištenja energije za balansiranje
- balansiranje očekivanih varijacija izlazne snage
- tržište električne energije
- zadovoljavajuća vrijednost LOLP

Kumulativni troškovi

Vrijednost indeksa *LOLP*

Ukupan iznos $CO_2$

Održiv EES BiH u „novim" uslovima rada

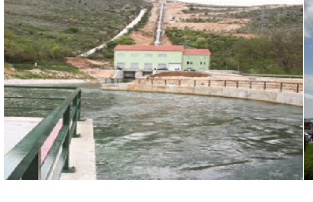
Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji

## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim" uslovima rada

***Polazni elektroenergetski sistem***

- Konvencionalna struktura proizvodnog portfolija
- Dominantna proizvodnja iz TE na ugalj
- Godišnja stopa porasta potrošnje 3,3% (predviđanja za EES zemalja u razvoju - prema *International Energy Outlook*)
- Vremenski period do 2035. godine
- Godišnja diskontna stopa 8%





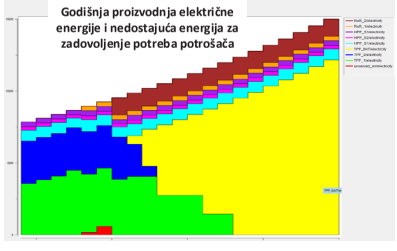


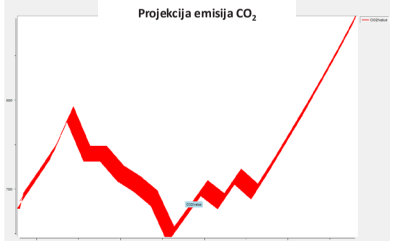
## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

***Model 0**: Model tradicionalnog pristupa planiranja razvoja – Polazni scenarij*

- Dosadašnja praksa razvoja proizvodnog portfolija EES-a u zemljama u razvoju (TE (BAT) i HE)
- Uvaženo smanjenje emisija $SO_x$ (NERP)
- Bez ograničenja na emisije stakleničkih gasova
- Bez značajne integracije proizvodnih jedinica na alternativne izvore

| | |
|---|---|
| Kumulativni troškovi (relativan iznos) | 1 |
| Vrijednost indeksa *LOLP* u granicama | DA |
| Ukupno $CO_2$ (relativan iznos) | 1 |





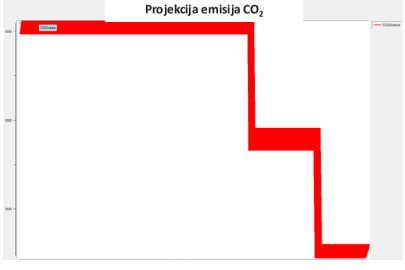

## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

***Model 1**: Model tradicionalnog planiranja razvoja uz poštivanje ograničenja emisija*

- Dosadašnja praksa razvoja proizvodnog portfolija EES-a u zemljama u razvoju (TE (BAT) i HE)
- Uvažena ograničenja na emisije $CO_2$ i $SO_x$ (NERP)
- Bez značajne integracije proizvodnih jedinica na alternativne izvore

| | |
|---|---|
| Kumulativni troškovi (relativan iznos) | 0,980 |
| Vrijednost indeksa *LOLP* u granicama | NE |
| Ukupno $CO_2$ (relativan iznos) | 0,846 |



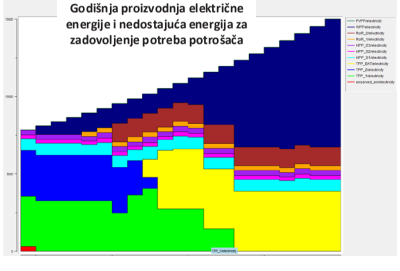


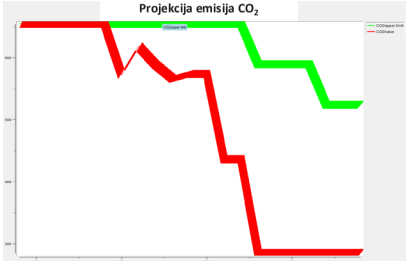

## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

***Model 2**: Model tradicionalnog planiranja razvoja uz intenzivnu integraciju VE i poštivanje ograničenja emisija*

- Uvažena ograničenja na emisije $CO_2$ i $SO_x$ (NERP)
- Intenzivna integracija VE

| | |
|---|---|
| Kumulativni troškovi (relativan iznos) | 0,894 |
| Vrijednost indeksa *LOLP* u granicama | - |
| Ukupno $CO_2$ (relativan iznos) | 0,664 |



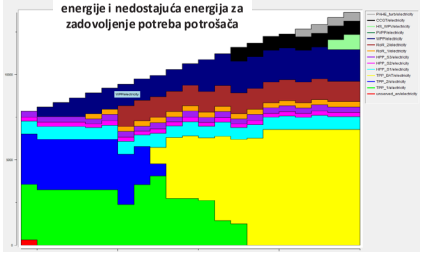


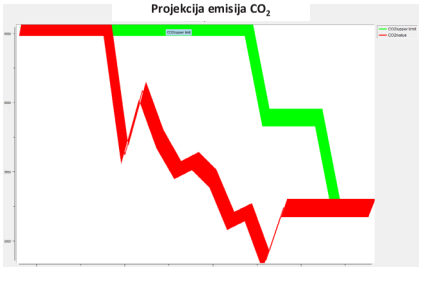

## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

***Model 3**: Miks model*

- Integracija proizvodnih jedinica na alternativne izvore (VE i FNE)
- Omogućena integracija CCGT, hibridnih sistema (HSVS, autonomni HS i PAHE - VE) i UVOZ
- Geografska disperzija proizvodnih jedinica na intermitentne izvore
- Uvažena ograničenja na emisije $CO_2$, $SO_x$ (NERP)

| | |
|---|---|
| Kumulativni troškovi (relativan iznos) | 0,846 |
| Vrijednost indeksa *LOLP* u granicama | DA |
| Ukupno $CO_2$ (relativan iznos) | 0,774 |



## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

➢ **Razmatrni faktori održivosti $F_i$ po modelima:**

- sistemski faktori: pouzdanost snabdijevanja, sigurnost snabdijevanja, efikasnost proizvodnog portfolija, neovisnost elektroenergetskog sistema, diverzifikacija proizvodnog portfolija,
- okolinski faktori: smanjenje emisija $CO_2$, smanjenje emisija polutanata, očuvanje biološke i kulturne raznolikosti, udio obnovljivih izvora u ukupnoj proizvodnji,
- ekonomski faktor: kumulativni troškovi;
- socijalni faktor: transfer tehnologija.

*Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji*

## Modeli tranzicije konvencionalnog elektroenergetskog sistema u sistem u „novim“ uslovima rada

➢ **Valorizacija faktora održivosti $F_i$ po modelima:**

| Faktori održivosti | Model 0 | Model 1 | Model 2 | Model 3 |
|---|---|---|---|---|
| Kumulativni troškovi (relativan iznos) | 1 | 0,980 | 0,894 | 0,846 |
| Vrijednost indeksa *LOLP* u granicama | DA | NE | - | DA |
| Ukupno $CO_2$ (relativan iznos) | 1 | 0,846 | 0,664 | 0,774 |

*Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji*

## Kako dalje?!

- Intenzivno koristiti „resurse“ energijske efikasnosti
- Intenzivirati korištenje OIE
- Uspostaviti regionalno tržište balansne snage kroz nove interkonekcije EES-a
- Razvijati hibridne sisteme na nivou mikromreža
- Koristiti tehnologije za pohranu električne energije
- Uspostaviti nove subjekte na mreži – „prosumer“ (donošenje regulative)
- Uspostaviti nove koncepte tržišta na principima block chain-a
- Uvezivati elektroenergetski sektor, sektor toplinarstva, te sektor hlađenja
- Koristiti tehnologije CCS i CCU




*Savjetovanje o budućnosti postojećih i novih termoelektrana u BiH u energetskoj tranziciji*

## Umjesto zaključka

**„Planovi su ništa, ali planiranje je sve“**
Dwight David Eisenhower (1890– 1969)

ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA (ANUBiH)

PUBLIC ENTERPRISE ELEKTROPRIVREDA OF BOSNIA AND HERZEGOVINA D.D. – SARAJEVO (EPBiH)

# USPOSTAVITI SISTEM KORIŠTENJA ZNANJA U RAZVOJU ENERGETSKOG SEKTORA BOSNE I HERCEGOVINE

**To establish a system of the implementation of knowldge in the development of the energy sector of Bosnia and Herzegovina**


dr. Aleksandar Knežević

IMPULSIO
POKRET ZA VLADAVINU ZNANJA
MOVEMENT FOR THE RULE OF KNOWLEDGE

a.knezevic@impulsio-sarajevo.org.


Sarajevo, 21. novembar 2019.

ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA

*SCIENTIFIC COLLOQUIUM*

**DECISION MAKING PRINCIPLES IN BUILDING OF ELECTRIC POWER SOURCES**

**PROGRAMME**

Sarajevo, March 27-28, 2008

AKADEMIJA NAUKA I UMJETNOSTI BOSNE I HERCEGOVINE
АКАДЕМИЈА НАУКА И УМЈЕТНОСТИ БОСНЕ И ХЕРЦЕГОВИНЕ
ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA

Special Editions
Volume CLXX

Department of Technical Sciences
Committee for Energy and Environment
Volume 18

Colloquium
ENERGY SECTOR OF BOSNIA AND HERZEGOVINA AT A CROSSROADS
The Role of Knowledge in Decision-making and Transitions

Sarajevo, November 30, 2016

## A. Umjesto uvoda

U ovoj državi postoji samo jedna stvar gora od političara.

To je akademska zajednica.

U ovoj državi nije važno šta znaš, nego koga znaš.

U bivšoj Jugoslaviji postojala je pitalica:

Šta je to, što je veće lakše se promaši?

Odgovor: investicija!

## A. Instead of an introduction

There is only one thing worse than politicians in this country.

It is an academic community.

In this country
it doesn't matter what you know,
but whom do you know

In the former Yugoslavia, there was a question mark:

What is it, the bigger the easier to miss?

Answer: investment


Šta se pojačava pred izbore?

Sindrom hidroelektrane u Suhom Dolu

PROPALE YU-INVESTICIJE

Starijim generacijama su poznate velike propale investicije u Jugoslaviji: Feni u Makedoniji, Obrovac u Hrvatskoj, hidroelektrana u gornjem toku Drine. Cilj je bio područja, ali su ene pogrešne e. Ili nije bilo ne ili se radilo o planovima gradnje na područjima koja moraju biti proglašena područjima zaštite prirode

Piše: prof. dr. Aleksandar Knežević

Sindrom hidroelektrane u Suhom Dolu je bolest poznata još iz socijalističke ere. Gradi se hidroelektrana, ljudi se zapošljavaju, u Suhi prihod od putarine, kao i povećani društveni proizvod kao rezultat aktivnosti u koridoru autoputa omogućiti vraćanje kredita uzetih za gradnju autoputeva. Niko ne govori da će kreirati uslove da, zahvaljujući proizvodnji objekata nego i razvoja na bazi izgrađenih objekata. Jer tek tu faza može doći do značajnog zapošljavanja ljudi i porasta životnog standarda građana. Postoje poslovi dugotrajnog značajnog zapošljavanja. To su

Syndrome of hydropower plant in Dry Valley


Samoubistvo iz zasjede elektroprivrednih organizacija Zapadnog Balkana

PROF. DR. ALEKSAN KNEŽEVIĆ

Suicide from the ambush of the Western Balkans electricity power plants


OSLOBOĐENJE

Piše: Prof. dr. Aleksandar Knežević;
Objavljeno: 05.07.2014.

Termoelektrane i održivi razvoj

Nije istina da imamo viška električne energije

It is not true that we have excess electricity

Upravljati troškovima a ne cijenama energije

**Pomozi čovjeku da potroši što manje energije**

Mogućnosti da se smanji potrošnja energije, i time poveća ekonomičnost privređivanja, ima ... periodu do tri godine, neki za nekoliko mjeseci, a neki ...amo za nekoliko dana

Manage costs, not energy prices

Help the person to consume as little energy as possible

Aleksandar Knežević: Energijska efikasnost vs. atavizam socijalizma

Prije nekih osam godina, posredstvom njemačke vladine organizacije GIZ, u Sarajevo je došlo nekoliko njemačkih stručnjaka za energiju da ispitaju uvjete za djelovanje ove organizacije u Bosni i Hercegovini. Pozvali su tad domaće stručnjake kako bi se informirali o stanju tog sektora u našoj zemlji

13. Mar 2016. | 16:41 | Prof. dr. Aleksandar Knežević

Energy efficiency vs. atavism of socialism



Buy energy or pay for energy service

**Kupiti energiju ili platiti energijsku uslugu**

Energija pokreće svijet i utječe na kvalitet života. Ona je sirovina u svim privrednim granama. No, ona zagađuje okolinu i izaziva klimatske promjene. Kako usaglasiti dobre strane energije i zahtjeve zaštite okoline i suzbijanja klimatskih promjena? Vrlo jednostavno i vrlo teško. Jednostavno – treba samo promijeniti način razmišljanja. Teško – jer se teško mijenja način razmišljanja

OSLOBOĐENJE • UTORAK, 20. DECEMBAR/PROSINAC 2016.

**Treba naučiti koristiti ugalj**

One must learn to use coal

...od države • Proizvodnje u sektoru umrežene energije biće velike

Piše: ALEKSANDAR KNEŽEVIĆ

OSLOBOĐENJE

**Pogledi, str. 27; 3. januar 2015**

Prof. dr. Aleksandar KNEŽEVIĆ

**Mada oni nisu pitali**

ODGOVORITE RUDARIMA

Answer the miners

KOLUMNA NOVO VRIJEME 41

Back-stop tehnologije za rudnike uglja u BiH

Back-stop technologies for coal mains

NOVO VRIJEME

Prof. dr. Aleksandar Knežević: Ozelenjavanje uglja u Bosni i Hercegovini

Vijesti Sport Ekonomija Intervju Kultura Obrazovanje Dijaspora English

Panorama Kolumne Porodica i zdravlje Životna sredina Fotografija Auto Tehnologija Fontana

Greening of coal in B&H

**Prof. dr. Aleksandar Knežević: Ozelenjavanje uglja u Bosni i Hercegovini**

Ugalj je crne boje, a crni scenarij razvoja elektroenergijskog sektora u Bosni i Hercegovini bio bi odustajanje od korištenja uglja. Bosna i Hercegovina dvije trećine električne energije osigurava iz termoelektrana na ugalj. U udžbenicima i štampi piše da smo bogati obnovljivim izvorima energije. Međutim, kad bi se koristili svi kapaciteti energije vjetra koji se spominju, ne bi se mogla osigurati proizvodnja koju bi omogućio blok TE Tuzla 7 snage 450 MW čija je izgradnja planirana. Trebamo ići ka obnovljivim izvorima energije, ali se od uglja ne može i ne treba tek tako odustati

28. Apr 2016. | 07:16 | Prof. dr. Aleksandar Knežević

Ugalj je crne boje, a crni scenarij razvoja elektroenergijskog sektora u Bosni i Hercegovini bio bi odustajanje od korištenja uglja.

Javno preduzeće ELEKTROPRIVREDA BOSNE I HERCEGOVINE d.d. - Sarajevo

POSLOVNA TAJNA

Informacija za Federalno ministarstvo energije, rudarstva i industrije

INFORMACIJA

O AKTIVNOSTIMA NA IZBORU PROJEKTNOG PARTNERA ZA ZAJEDNIČKO ULAGANJE U PROJEKAT IZGRADNJE BLOKA 7 U TE TUZLA

Treća faza tenderskog procesa

Maj 2014.

**B. U čemu je stvar ?**

Nemoguća kombinacija

An impossible combination

UK | BiH Reform assistance to Bosnia and Herzegovina

Podrška reformama u Bosni i Hercegovini

(Framework of energy strategy in Federation of B&H to 20135.)

OKVIRNA ENERGETSKA STRATEGIJA FEDERACIJE BOSNE I HERCEGOVINE DO 2035.

Status dokumenta: Radna verzija v.02
Datum predaje verzije: 6.6.2017.

Delphos International

STUDIJA IZVODIVOSTI

IZGRADNJA BLOKA 7 U TERMOELEKTRANI TUZLA



Novembar 2016

Praksa energetske politike

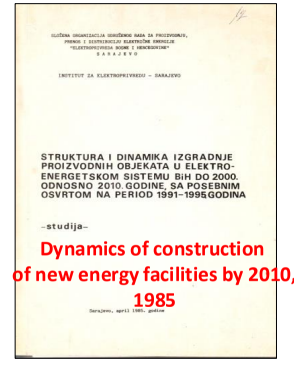
Practice of energy policy in B&H

**B. What is a problem?**




Documentary of the League of Communists of Yugoslavia, 1983

Deveta sjednica CK SKJ; prilagođavanje privrednog sistema zahtjevima stabilizacije razvoja pravnog sistema sa stanovišta ekonomske stabilizacije, regionalni aspekt razvoja Jugoslavije; strategija i osnove politike razvoja; Sarajevo, 1983.



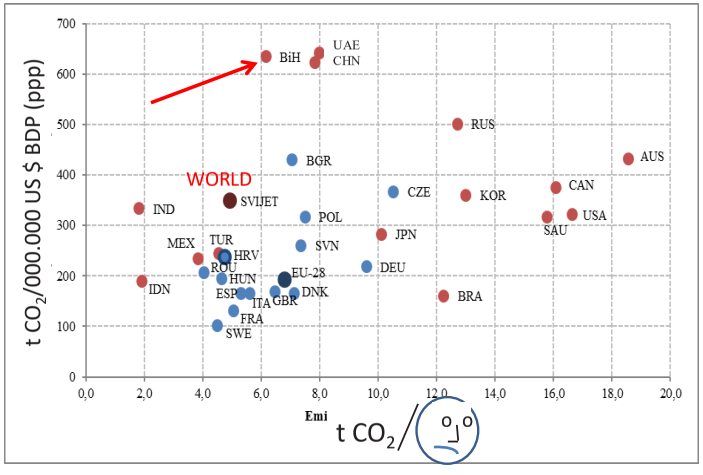

Dynamics of construction of new energy facilities by 2010, 1985

Struktura i dinamika izgradnje proizvodnih objekata u elektro-energetskom sistemu bih do 2000. odnosno 2010. godine, sa posebnim osvrtom na period 1991-1995. godina -studija-

Složena organizacija udruženog rada

za proizvodnju, prenos i distribuciju električne energije "Elektroprivreda Bosne i Hercegovine" Sarajevo; institut za elektroprivredu – Sarajevo; Sarajevo, april 1985. godine

**Karbonska intenzivnost - Carbon intensity**




izvor: Strategija niskougljeničnog razvoja Hrvatske, 2017
Source: Strategy of low carbon development of Croatia, 2017

Uzroci visoke karbonske intenzivnosti u Bosni i Hercegovini:
- struktra poštrošača energije
- niska efektivnost vlasti i
- niska energijska efikasnost.

Ne postoji projekat u BiH sa većom potencijalnom efektivnošću od povećanja energijske efikasnosti.

To ne znači odustajanje od gradnje TE Tuzla 7, nego znači mogućnost formiranja realne cijene električne energije na tržištu.

Causes of high Carbon intensity in Bosnia and Herzegovina:
- the structure of the energy consumer
- low government effectiveness and
- low energy efficiency.

There is no project in BiH with greater potential effectiveness from increasing energy efficiency.

This does not mean that the construction of TPP Tuzla 7 should be backtracked but means being able to form a realistic price for electricity on the market

**Prvi čas na predmetu Ekonomika energije**

Upravljati troškovima, a ne cijenama energije.

Cijene energije rastu i treba da rastu,
ali troškovi korištenja energije ne smiju da rastu.

To se postiže primjenom principa mrkve i batine,
pri čemu je batina najava da će energija stalno poskupljivati,
a mrkva vladine mjere da ne porastu troškovi korišenja energije.

Energy prices are rising as they should rise, but the costs of its use must not follow suit.

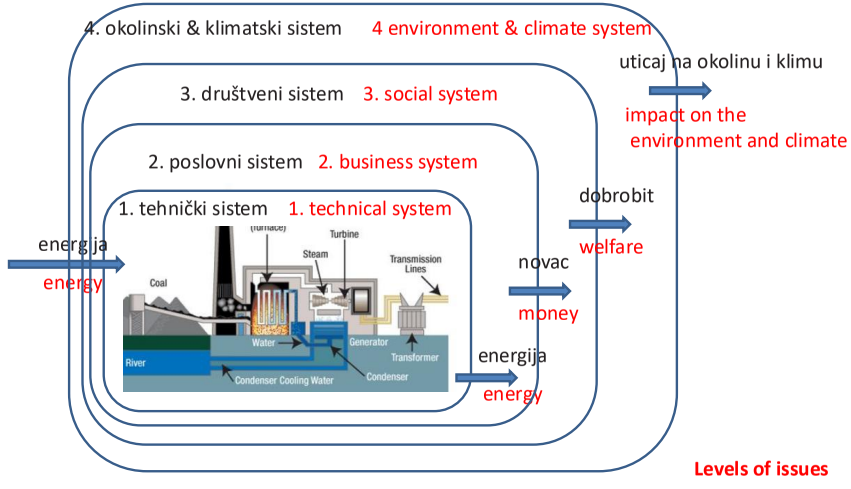
**First lecture on Energy Economics**

Manage costs, not energy prices.

Energy prices are rising and should be rise,
but energy costs should not rise.

This is achieved by applying the carrot-and-stick principle,
where the announcement that the price of energy will be steadily rising is a proverbial stick,
and the government measures to prevent the costs of electricity from rising play a role of carrot.

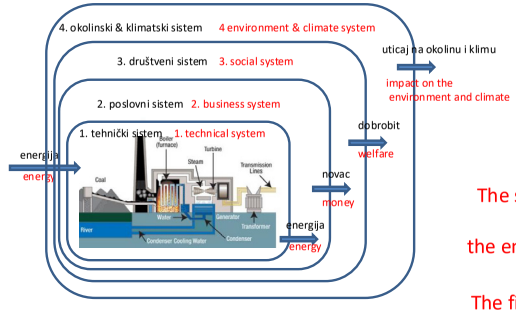
**Nivoi problematike**




**Levels of issues**

I energetska strategija (nivo 3)
i projekat tehničkog sistema TE (nivo 1)
treba da obrade sva četiri nivoa

Takav pristup poboljšava
održivost poslovnog sistema (2)




Finansijska održivost TE Tuzla 7 je upitna,
ali sigurno postoji društveno-ekonomska
održivost

Povećanjem energijske efikasnosti
potrošača energije moguće je
povećati održivost poslovnog
sistema.

Both the energy strategy (level 3) and
the TPP technical system
project (level 1)
should handle all four levels.

Such an approach enhances
business system sustainability (2)

The sustainability of the business system
can be increased by increasing
the energy efficiency of energy consumers

The financial sustainability of TPP Tuzla 7
is questionable, but surely there is
socio-economic sustainability

Akademija nauka i umjetnosti Bosne i Hercegovine
Odjeljenje tehničkih nauka
Odbor za energiju, energetiku i okoliš

Sarajevo, 20. 12. 2017. godine

**STAV O OKVIRNOJ ENERGETSKOJ STRATEGIJI BOSNE I HERCEGOVINE DO 2035. GODINE**

*SAOPŠTENJE ZA JAVNOST*

Polazeći od misije, ciljeva i primarnih zadataka Odbor za energiju, energetiku i okoliš formiran pri Odjeljenju tehničkih nauka ANUBiH, razmotrio je, na sjednici održanoj u decembru, finalni nacrt Okvirne energetske strategije Bosne i Hercegovine.

**Negodovanja u vezi**
**Okvirne energetske strategije BiH**
**• pet profesora sa**
**tri bh. univerziteta i**
***Odbor za EEO ANU BiH**

Statement of B&H Energy Strategy - Press Release




**Resentments in a relationship**
**the framework energy strategies of BiH**
**- five professors with**
**three B&H universities and**
**- EEE ANUBiH Board**

prof. dr. Azrudin Husika
prof. dr. Nasiha Pozder
prod. dr. Sanela Klarić

Politike okoliša koje nose ekonomski razvoj BiH
ANALIZA OKVIRNE ENERGETSKE STRATEGIJE BIH DO 2035. GODINE

SOCIJALDEMOKRATA

## Netransparentnost

Cijeli postupak izrade okvirne energetske stragije i studija vezanih za razvoj energetskog sektora i pojednih termoelektrana se odvijao u strogoj tajnosti.

## Non-transparency

The whole process of creating a framework energy strategy and studies related to the development of the energy sector and some thermal power plants were kept strictly confidential.

**Troškovi garancije od strane Vlade FBiH**
**za zaduživanje Elektroprivrede BiH kod kineske eksim banke**

Senad Salkić, izvršni direktor za investicije Elektroprivrede BiH: Elektroprivreda BiH će u ime dobivanja garancije Vladi FBiH:
• uplatiti nešto više od 40 miliona KM,
• dati pod hipoteku dva vrijedna energetska objekta kao kolateral, te
• asignaciju na određeni broj velikih kupaca (naplata u periodu od pet godina).

izvor: http://www.federalna.ba/bhs/vijest/268733/otvoreni-studio-13032019 (18-ta minuta)

**Gradnja termoelektrane Tuzla – blok 7**
**Iznos novca koji će se utrošiti na teritoriji Bosne i Hercegovine**

Od ukupne vrijednosti kredita za izgradnju TE Tuzla 7 tačno 33 % će biti utrošeno u Bosni i Hercegovini za radove od strane bh. preduzeća.

Nermin Đindić, Ministar za energiju, industriju i rudarstvo FBiH; Radio bh 1, 1. juni 2019 (zabilježio A. Knežević)

**Nema javne recenzije**

**No public review**

## C. Prijedlog

1. Uvesti sistem hibridnih instituta za energiju - povezati raspoloživ kadar, elektroenergetske organizacije i političare – nosioce vlasti.

Centralno mjesto u uspostavljenim sistemima je Sistem kvaliteta, koji mora postojati, koji je javan i koga se treba pridržavati.

Slijede sedam modela sistema.

2. Javna preduzeća treba da podležu javnoj recenziji projekta.

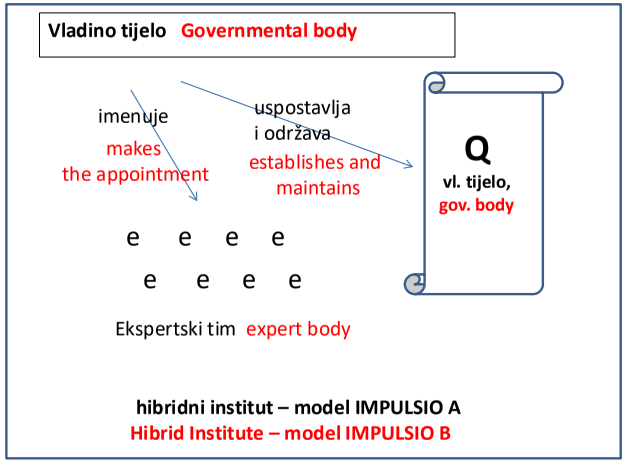
## C. Proposal

1. To instal a system of hibrid energy institutes - to interconnect available professionals, power organizations and policy-makers

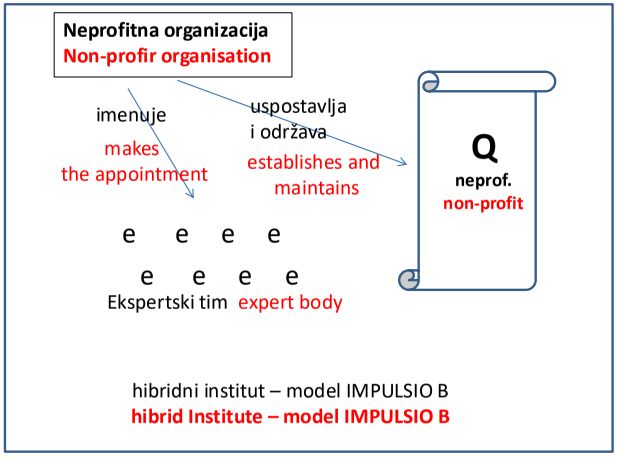
Central to established systems is a Quality system, which must exist, who is public and who should be adhered to.

The following are seven model systems.

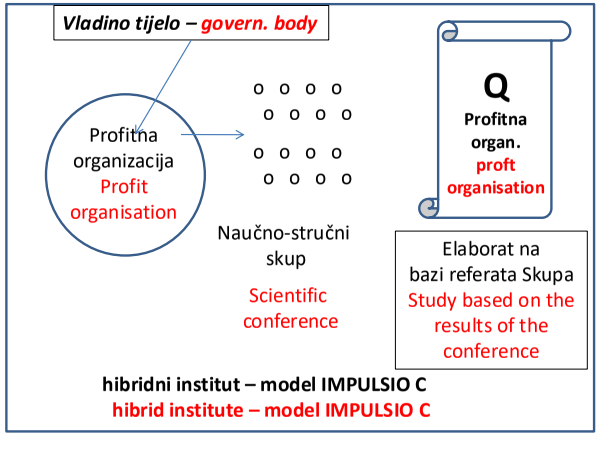
2. Public companies should be subject to public review of the project.



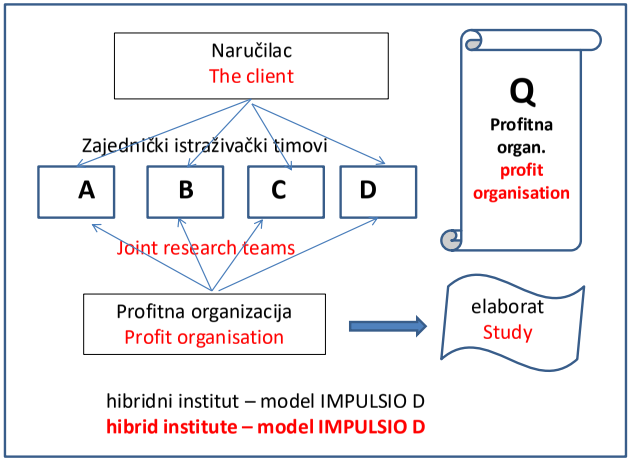

**hibridni institut – model IMPULSIO A**
**Hibrid Institute – model IMPULSIO B**



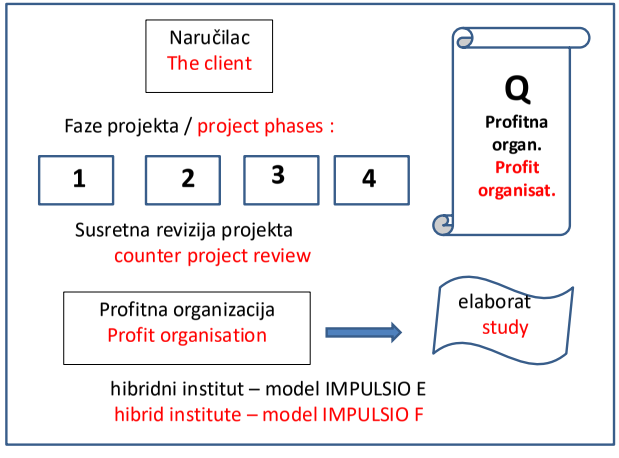

hibridni institut – model IMPULSIO B
**hibrid Institute – model IMPULSIO B**

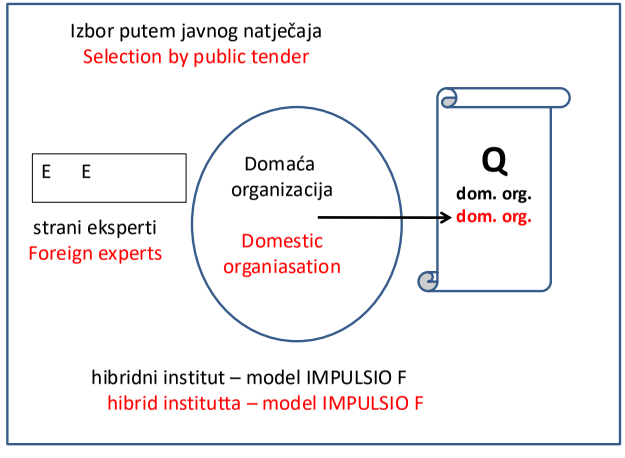


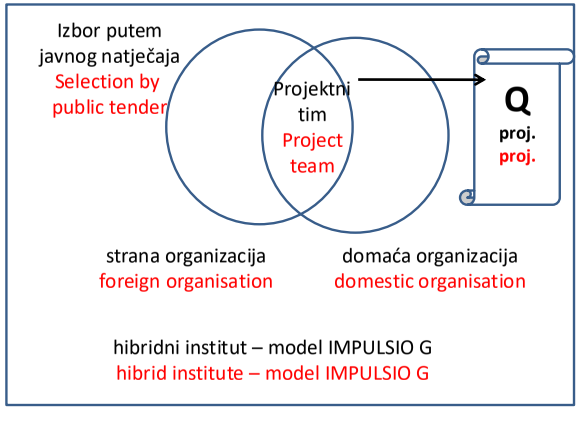

**hibridni institut – model IMPULSIO C**
**hibrid institute – model IMPULSIO C**




hibridni institut – model IMPULSIO D
**hibrid institute – model IMPULSIO D**




## Zaključak

Kroz energetske projekte razvijati domaće znanje. Domaće znanje će to višestruko da vrati.

Ponuđen je veći broj modela uključivanja domaćeg znanja u Projekte.

Krucijalna stvar je utvrđivanje **sistema kvaliteta** koji će biti korišten kod realizacije projekta.

Projekti javnih preduzeća treba da podležu **javnoj recenziji.**

k r a j

## Conclusion

Through energy projects develop local knowledge. Domestic knowledge will multiple to give back.

A number of models of incorporating local know-how into projects have been offered.

It is, of course, crucial to have the **quality system** established that will be used in the project implementation.

Public company projects should be subject to **public review**.

t h e e n d

# Povećanje snage, efikasnosti i uvođenje savremenih tehnologija za smanjenje zagađenja životne sredine u termoelektranama Srbije

Predrag Stefanović [1*], Dejan Cvetinović [1], Zoran Marković [1], Milić Erić [1]
**e-mail: pstefan@vinca.rs**
[1] Univerzitet u Beogradu, Institut za nuklearne nauke "Vinča", Laboratorija za termotehniku i energetiku, P.p 522, 11001 Beograd, Srbija



## Proizvodnja u JP ELEKTROPRIVREDA SRBIJE 2001. godine (bez postrojenja na Kosovu i Metohiji)

| Za ugalj 2001. godine | Proizvodnja uglja Mt | Za TE Mt | Za ostale potrošače | Proizvodnja otkrivke $Mm^3$ |
|---|---|---|---|---|
| Kolubarski basen | 25,334 | 23,378 | 1,956 | 38,172 |
| Kostolački basen | 5,165 | 4,897 | 0,268 | 11,864 |
| Podzemna eksploatacija | 0,555 | 0,112 | 0,443 | |

| Za električnu energiju 2001. godine | Snaga na pragu $MW_e$ | Proizvodnja GWh/god | Udeo u ukup. proizvodnji % |
|---|---|---|---|
| TE na ugalj | 3936 | 18973 | 63,1 |
| TE-TO na gas/tečno gorivo | 353 | 466 | 1,6 |
| Hidroelektrane | 2831 | 10622 | 35,3 |

NAUČNO-STRUČNO SAVJETOVANJE
BUDUĆNOST POSTOJEĆIH I NOVIH TERMOELEKTRANA U BOSNI I HERCEGOVINI U ENERGETSKOJ TRANZICIJI
21. novembar 2019. godine, Akademija nauka i umjetnosti Bosne i Hercegovine, Bistrik 7, 71000 Sarajevo

## Povećanje snage i efikasnosti termoblokova na lignit u JP EPS-u

**Problema pouzdanosti i sigurnosti rada termoblokova kao i veliki broj neplanskih ispada (zbog havarija pre svega na cevnom sistemu kotla) tj. skraćeni period rada na mreži i sa smanjenom snagom u odnosu na nominalnu su bili osnovni problem na početku XXI veka. Paralelno sa rešavanjem ovih problema kroz projekte produženja radnog veka bloka, rađeno je na uvođenju digitalnih sistema upravljanja, povećanju produkcije kotla, povećanju snage i efikasnosti blokova na lignit.**

**Faza 1.** Svaki od ovih projekata je imao obimne i složene pripreme (kao što su: detaljna analiza rada/otkaza, sistematsko uzorkovanje u cevnom sistemu kotla, analiza naslaga i korozionih oštećenja u uzorcima, procena preostalog veka pojedih komponenti cevnog sistema/postrojenja, termotehnička merenja parametara rada pojedinih postrojenja, idejno rešenje, tehno-ekonomsku analizu opravdanosti investicija u predloženo rešenje kao i izradu tehničke i tenderske dokumentacije za izvođenje).

**Faza 2.** Za realizaciju projekta bitno je formiranje kvalitetne i iskusne stručne komisije za praćenje kvaliteta i dinamike realizacije projekta jer se najčešće na istom bloku finalizuju paralelno više različitih projekata tj. istovremeno, u kratkom vremenskom periodu tokom godišnjih ili kapitalnih remonata.

**Faza 3. Na kraju realizacije projekta nezavisna akreditovana institucija sa odgovarajućim referencama vrši garancijska ispitivanja (Test A) a na kraju garantnog perioda i ponovljena garancijska ispitivanja (Test B).**

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## Povećanje snage i efikasnosti 2 termobloka TE Kostolac B 2*348,5 MW

**Kotao SES Tlmače po licenci Sultzer, turbina Zalmeg i generator Dolmel Poljska Od početka rada (B1 od 1989 i B2 od 1991) i pored nastojanja isporučioca opreme, oba bloka su imala trajnu snagu ispod 320 MW a kasnije ispod 300 MW.**

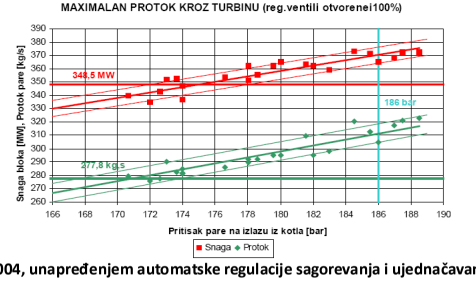
**Detaljna i brojna ispitivanja su ukazala na brojne razloge za to: a) nepravilno projektovan sistem napajanja kotla vodom zbog čega je dolazilo do kavitacije i nekoliko havarija napojnih pumpi pa je projektant ograničio njihov kapacitet u cilju sprečavanja ponovnih havarija pumpi, ali je time i ograničio snagu bloka na 320-330 MW; b) mlinska postrojenja nisu mogla dostići nominalni kapacitet od 76 tuglja/h jer su kanali aerosmeše poddimenzionisani i stvarali veliki otpor kao i nepravilnu raspodelu ugljenog praha i gasne smeše po visini gorionika i ložišta, c) nepravilna organizacija sagorevanja uz podignutu vatru u ložištu, pojavu zašljakivanja, povećani otpor u gasnom i parnom traktu, pregrevanje metala cevnog sistema, nepravilnosti u regulaciji rada bloka, nepravilnosti u održavanju režima kvaliteta napojne vode itd.**

Otklanjanje uočenih nedostataka je realizovano u više faza: rekonstrukcija kanala aerosmeše 1998, modernizacija sistema napajanja kotla vodom i skidanje ograničenja kapaciteta napojnih pumpi 2002, detaljna termotehnika i bilansna ispitivanja kotla uz kratkotrajna dostizanja snage iznad 340 MW, zaptivanje LUV-a, ložišta i mlinskih krugova u cilju smanjenja prisisa hladnog „falš" vazduha, ugradnja žaluzina u aerokanale, unapređenje organizacije sagorevanja u ložištu, unapređenje regulacije temperature pare iza P2, hemijsko čišćenje dela cevnog sistema i unapređenje kvaliteta napojne vode.

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## Povećanje snage i efikasnosti 2 termobloka TE Kostolac B 2*348,5 MW

**Detaljna ispitivanja posle remonta 2003. godine pri radu bez automatske regulacije sagorevanja su ukazala na mogućnost ostvarenja produkcije pare i do 1150 t/h i snage bloka do 375 MW uz garantovane stepene korisnosti kotla ≥87%**




**Tokom 2004, unapređenjem automatske regulacije sagorevanja i ujednačavanjem dotoka uglja iz bunkera, granulacije ispod 60 mm, znatno su ublažene i oscilacije parametar kotla!**



## Povećanje snage i efikasnosti termobloka TENT A6 (308,5MW)

**Kotao RAFAKO po licenci Sultzer, turboagregat CEM Francuska**
**Pušten u rad 1979, 2 teške havarije na turbopostrojenju i dugotrajne zastoje 1. od 29. 12. 1985. do 23. 6. 1988, i 2. od 10. 7. 1989. do 27. 4. 1991.**
**Rad na revitalizaciji i podizanju snage u periodu od 2006 do 2010. god.**
**Detaljna ispitivanja su ukazala da postoje značajne rezerve na generatoru i blok trafou a da će glavni radovi/investicije biti na kotlovskom i turbinskom postrojenju.**
**Remontni radovi 2008. i 2010. godine. Na kotlovskom postrojenju: 1. Cevni sistem kotla i parovodi-savremni čelici i povećan svetli otvor, 2. Unapređenje zaptivanja LUV-a, ložnog uređaja, ložišta i dimnog trakta 3. Podizanje kapaciteta mlinova sa 100 na 110 t/h i spuštanje jezgra plamena (ugradnja novih aero kanala sa žaluzinama za preraspodelu ugljenog praha po visini gorionika) 4. podizanje produkcije pare sa 920 na 1050 t/h i stepena korisnosti kotla sa 84% na 88%. Modernizacija EF za emisiju <50 mg/Nm³. Na turbinskom postrojenju: 1. retrofit TVP, TSP, kompletne ventilske blokove TVP i TSP i unutrašnji modul TNP, 2. Zamenjene kondenzatorske cevi, vraćanje u funkciju ZVP.**
**Garancijska ispitivanja kotla, EF i turbinskog postrojenja izvršena su početkom 2011 i potvrdila garantovane parametre!**



## Povećanje snage i efikasnosti termobloka TENT A6 (308,5MW)

| Nominalni režim Parametar | | Originalno stanje | Posle modernizacije |
|---|---|---|---|
| Električna snaga | MW | 308,5 | 348,4 |
| Maseni protok sveže pare | t/h | 920 | 975 |
| Pritisak sveže pare na ulazu u turb. | bar | 177,5 | 177,5 |
| Temperatura sveže/pregrejane pare | °C | 540/540 | 540/540 |
| Pritisak u kondenzatoru | bar | 0,049 | 0,055 |
| Specifična potrošnja toplote turbopostrojenja bruto | kJ/ KWh | 7815 | 7719,5 |

**u 2011 godini, termoblok na lignit TENT A6 je ostvario najduži rad na mreži od 8224 h i od svoje prve sinhronizacije ostvario najveću godišnju proizvodnju od 2484 GWh. Ostvarena prosečna (na nivou cele 2011. godine) snaga na mreži od oko 302 MW!**



## Proizvodnja u JP ELEKTROPRIVREDA SRBIJE 2011/2001. godine (bez postrojenja na Kosovu i Metohiji)

| 2011 ------ = % 2001 | Proizvodnja uglja Mt/god | Za TE Mt/god | Za ostale potrošače Mt/god | Proizvodnja otkrivke Mm³/god |
|---|---|---|---|---|
| Kolubarski basen | 31,061 -------- = 122,6% 25,334 | 29,355 -------- = 125,6% 23,378 | 1,706 -------- = 87,2% 1,956 | 71,67 -------- = 187,8% 38,17 |
| Kostolački basen | 9,230 -------- = 178,7% 5,165 | 8,873 -------- = 181,2% 4,897 | 0,357 -------- = 133,2% 0,268 | 39,54 -------- = 333,2% 11,867 |

| Električne energije | 2001 [GWh] | 2011 [GWh] | Povećanje [%] |
|---|---|---|---|
| PD TENT | 16150 | 20205 | 125,1 |
| PD Kostolac | 2823 | 6257 | 221,6 |

## Povećanje snage i efikasnosti termobloka TENT B1 (618,5MW)

Kotao RAFAKO po licenci Sultzer, turboagregat BBC/ALSTOM ATLANTIQUE
Pušten u rad 1983, i do kraja 2011. godine je ostvario > 200000 h na mreži i isporučio 107 000 GWh
Rad na revitalizaciji i podizanju snage u periodu od 2007. god. Detaljna ispitivanja su ukazala da će u cilju podizanja produkcije sa 1880 na 2000t/h i snage na 665,2 MW, glavni radovi/investicije biti na kotlovskom i turbinskom postrojenju.
I Faza: Remontni radovi od 2008. do 2012. godine. Na kotlovskom postrojenju: 1. Deo isparivača iznad kote 72m zamenjen-savremni čelici i povećan svetli otvor, zamena P2, MP2 i MP3 2. Ugrađen dodatni EKO 1A u pararleli sa EKO 1 radi dodatnog iskorišćenja otpadne energije dimnih gasova 3. Podizanje kapaciteta mlinova na 140 t/h i spuštanje jezgra plamena (ugradnja žaluzinama za preraspodelu ugljenog praha po visini gorionika) 4. podizanje produkcije pare sa 1880 na 1990 t/h. Modernizacija EF za emisiju <50 mg/Nm$^3$. Na turbinskom postrojenju: 1. Komplet nova TVP, zamena rotorskih lopatica na stupnjevima 1-15 na TSP, stupnjevima 1-5 TNP1 stupnjevima 1-4 TNP2, 2. Zamenjene kondenzatorske cevi, vraćeni su u funkciju ZVP
Garancijska ispitivanja EF i turbinskog postrojenja izvršena početkom 2013 su potvrdila emisiju PM< 50mg/Nm$^3$ i mogućnost ostvarenja ciljne produkcije kotla i snage bloka ali se zbog velikog pada pritiska u vodeno-parnom traktu kotla, mora izvršiti i Faza II gde će se zameniti preostali deo isparivača sa povećanim svetlim otvorom, i uvesti primarne mere za smanjenje emisije NOx < 200mg/Nm$^3$ i CO < 200mg/Nm$^3$



## Povećanje snage i efikasnosti termobloka TENT A3 (305 MW)

U kapitalnom remontu 2014 godine uvedene su primarne mere za smanjenje emisije NOx < 200mg/Nm$^3$ i CO < 200mg/Nm$^3$, modernizovan je EF za emisiju PM < 50mg/Nm$^3$ i modernizovana je turbina u cilju povećanja snage bloka na 328,5 MW pri nominalnom režimu (bez povećanja prdukcije pare u kotlu)

Garancijska ispitivanja EF, kotlovskog i turbinskog postrojenja izvršena početkom 2015 su potvrdila ostvarenje svih ciljanih parametara!

## Povećanje snage i efikasnosti termobloka TENT A4 (308,5MW)

U kapitalnom remontu 2018 godine uvedene su primarne mere za smanjenje emisije NOx < 200mg/Nm$^3$ i CO < 200mg/Nm$^3$, unapređen je EF za emisiju PM < 50mg/Nm$^3$ i modernizovana je turbina u cilju povećanja snage bloka na 332,8 MW pri nominalnom režimu (bez povećanja prdukcije pare u kotlu) i maksimalno na 342,9 MW.
Garantovana specifična potrošnja toplote turbo postrojenja <7764 kJ/kWh,
Vrednost: investicije 41+donacija 8,5+remontni radovi 4M€

Garancijska ispitivanja EF, kotlovskog i turbinskog postrojenja izvršena krajem 2018 su potvrdila ostvarenje svih ciljanih parametara!

NAUČNO-STRUČNO SAVJETOVANJE
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## Problem ujednačavanja kvalitetat uglja koji se isporučuje termolektranama

Problem ujednačavanja kvaliteta lignita koji se sa površinskih kopova isporučuje termoelektranama je bio prisutan od početka rada termoelektrana.
Problem je vrlo izražen kod lignita iz Kolubarskog basena, a naročito je akutan od 2014 godine, posle velikih poplava na glavnim kopovima koje su napravile ogromne štete i smanjenu proizvodnju lignita i struje u TENT-u u narednim godinama).

Samo obnova, čišćenje i modernizacija rudarske opreme koja je poplavljena 2014. godine koštala je 29,5 M€).

Studija koju smo radili 2010. godine je kvantifikovala veliki uticaj promenljivog kvaliteta kolubarskog lignita na efikasnost rada kotlova, potrošnju tečnog goriva, raspoloživost i proizvodnju termoblokova (naročito u zimskom periodu kada je struja najpotrebnija) ali i efikasnost savremenih tehnologija za smanjenje zagađenja životne sredine.
U uslovima velikih i brzih promena kvaliteta lignita kakva su danas prisutna, naročito je otežana efikasana primena primarnih mera za smanjenje emisije azotnih oksida ali i efikasan rad elektrofilterskih postrojenja.

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## Problem ujednačavanja kvalitetat uglja koji se isporučuje termolektranama

Na bazi ove dokumentacije odobren je međunarodni "zeleni" kredit za uvođenje sistema upravljanja kvalitetom lignita (uključujući i selektivno otkopavanje i homogenizaciju) u zapadnom delu Kolubarskog basena (projekat 54,4 M€, finansiran kreditom KfW banke + donacije banke+ učešće EPS-a).

Takođe je planiran projekat uvođenja sistema upravljanja kvalitetom lignita u istočnom delu Kolubarskog basena (projekat 90 M€, finansiran od EPS-a). Ovi projekti treba da obezbede ujednačavanje kvaliteta uglja, podizanja energetske/poslovne efikasnosti i snage a smanjenja emisije iz Termolektrana "Nikola Tesla" koje proizvode 50 % struje u Srbiji.

U Kostolačkom basenu od 2010 godine u eksploataciji je samo površinski kop "Drmno" a lignit je relativno ujednačenog kvaliteta ali sa relativno velikim sadržajem sumpora i sklon ka zašljakivanju. Projekat uvođenja sistema upravljanja kvalitetom lignita iz površinskog kopa "Drmno" je realizovan (vrednost 5,23 M€) a u završetku je i projekat (iz kineskog kredita) podizanja kapaciteta sa 9Mt/god na 12Mt/god za potrebe novog termo bloka TE Kostolac B3 snage 350 MW.

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## Uvođenje savremenih tehnologija za smanjenje zagađenja iz TE

| JP EPS termoblok na lignit | Elektro filteri | Mere za smanjenje NOx | | Postrojenje DeSOx | Novi sistem transporta pepela | Tretman otpadnih voda |
|---|---|---|---|---|---|---|
| | | Primarne | Sekundarne | | | |
| TENT A1 | 2007 | Planirano za 2022. godinu procena investicije 36M€ | | | Zajedničko za TENT A1-A6 2018 | Zajedničko za TENT A1-A6 2018 |
| TENT A2 | 2006 | Planirano za 2023. godinu procena investicije 36M€ | | | | |
| TENT A3 | 2014 | 2014 | | Zajedničko za TENT A3-A6 u izgradnji | | |
| TENT A4 | 2008/2018 | 2018 | | | | |
| TENT A5 | 2005 | 2015 | | | | |
| TENT A6 | 2010 | 2010/2020/12,2M€ | | | | |
| TENT B1 | 2012 | 2021/ 12,3M€ | | Zajedničko TENT B1-B2 190 M€ | 2012 | |
| TENT B2 | 2011 | 2022/ 12,3M€ | | | | |



## Uvođenje savremenih tehnologija za smanjenje zagađenja iz TE

| JP EPS termoblok na lignit | Elektro filteri | Mere za smanjenje NOx | | Postrojenje DeSOx | Novi sistem transporta pepela | Tretman otpadnih voda |
|---|---|---|---|---|---|---|
| | | Primarne | Sekundarne | | | |
| TE Kolubara A1 | | 32 MW Planirano zatvaranje juna 2022, preostalo 11026 radnih sati na dan 1.01.2019. | | | | |
| TE Kolubara A2 | | 32+65+32 MW Planirano zatvaranje jula 2021, preostalo 8712 radnih sati na dan 1.01.2019. | | | | |
| TE Kolubara A3 | | | | | | |
| TE Kolubara A4 | | | | | | |
| TE Kolubara A5 | 2010 | 110 MW Planirano zatvaranje decembra 2023, preostalo 14650 radnih sati na dan 1.01.2019.dan | | | | |
| TE Morava | 2016 | 125 MWPlanirano zatvaranje jula 2022, preostalo 11158 radnih sati na dan 1.01.2019. | | | | |
| TE Kostolac A1 | 2005 | planirana Investicija 27M€ | | | 2018 | 2022 |
| TE Kostolac A2 | 2008 | 2022/ 10M€ | | 2023./49M€ | | |
| TE Kostolac B1 | 2014 | 2014 | | 2017 | 2014 | 2020 |
| TE Kostolac B2 | 2012 | 2019-2020/ 12,3M€ | | 2017 | | |
| TE Kostolac B3 | √ | √ | | √ | √ | √ |



## Novi Termo blok Kostolac B3 350 MW u izgradnji !

| Investicija | M$ | 715,6 |
|---|---|---|
| Snaga na generatoru | MW | 350 |
| Produkcija sveže pare | t/h | 1032 |
| Pritisak sveže pare | MPa | 25,4 |
| Temperatura sveže pare | °C | 271 |
| Stepen korisnosti kotla | % | 88,8 |
| Bruto specifična potrošnja bloka | kJ/kWh | 8571,43 |
| Sopstvena potrošnja bloka | % | 11,98 |
| Bruto/neto termiki stepen korisnosti bloka | % | 42/37 |
| Emisija PM, Nox, SOx | mg/Nm$^3$ | 10/200/150 |



# Power Generation Flexibilisation Case Studies from Germany

Ronald Rost, Dragomir Marković, Zoran Božović

VPC Sustainable Engineering & Consulting

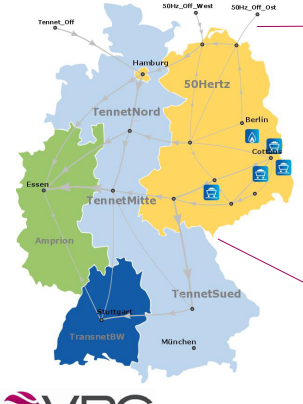
## Agenda

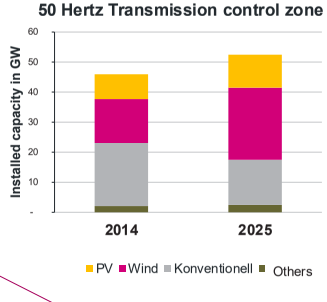


- **Need for Flexibilisation**
- flexGen Jaenschwalde
- Moorburg Flexibilisation
- CCGT Leipzig
- SMM-EMS Regulatory Area



## The German Power System






## Effects on conventional power plants

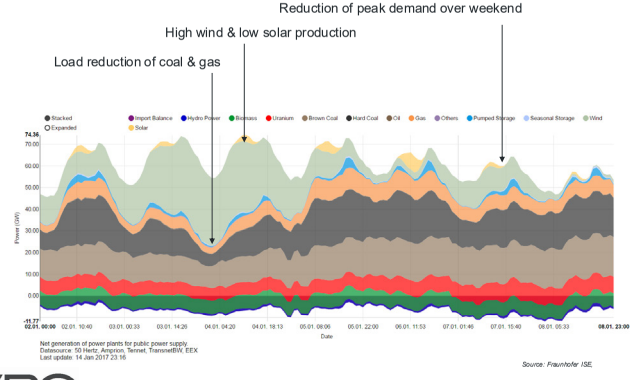
**Trend**

- Increasing number of extreme situations with generation peaks
- Decrease in continuous generation
  - Increasing re-dispatch interventions
  - Falling Electricity market prices

**Consequences for the power plant operators**

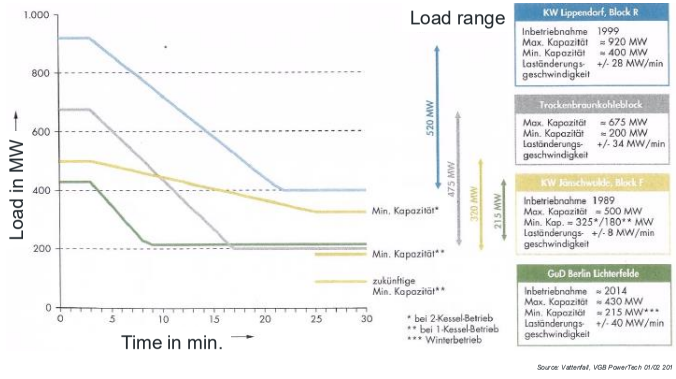
- Frequent ramping, start-up and shut-down of conventional capacities
  - Rising maintenance costs
  - Less full load operating hours
  - Rising costs of power generation
- Price fluctuations on the EEX power exchange
  - Falling wholesale prices
  - Increasing of uneconomical operating phases
- Increasing requirements by Federal Network Agency
  - Rising operational expense for operators (±10MW)

## Power production in Germany – calendar week 01/2017



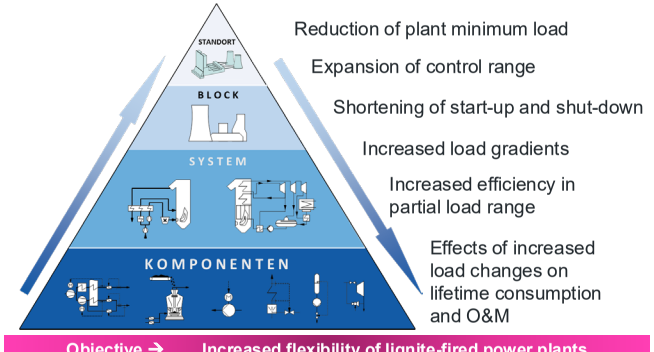



## Load flexibility comparison of Vattenfall's conventional plants






## Focal points of Vattenfall's flexGen program




- Reduction of plant minimum load
- Expansion of control range
- Shortening of start-up and shut-down
- Increased load gradients
- Increased efficiency in partial load range
- Effects of increased load changes on lifetime consumption and O&M

**Objective → Increased flexibility of lignite-fired power plants**

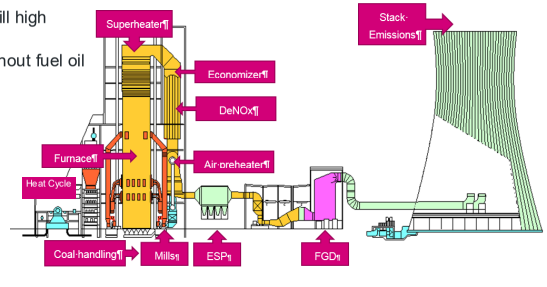


## Background – Impact on plant components

Requirements on power plants:

- Increasing number of start-up and shut down process
- Speed of load change with a still high efficiency
- Reduction of minimum load without fuel oil support
- Shortening of start up time

Impact on components



## Agenda



- Need for Flexibilisation
- **FlexGen Jaenschwalde**
- Moorburg Flexibilisation
- CCGT Leipzig
- SMM-EMS Regulatory Area



## Power Station Jaenschwalde (6 x 500 MW)

| | | |
|---|---|---|
| **Construction period** | | 1977–1988 |
| **Continuous operation** | | 1982/1985/1988 |
| **Technical data:** | | |
| Live steam temperature | °C | 535 |
| Live steam pressure | bar | 172 |
| Intermediate steam temp. | °C | 540 |
| Live steam delivery | kg/s | 2 x 226 |
| Preheating stages | | 7 |
| Feed-water temperature | °C | 245 |
| Cooling water temp. | °C | 20 |
| Exhaust steam pressure | mbar | 50 |
| Generator output | MW | 530 |
| Fuel | | lignite, RDF |
| Heat extraction | $MW_{th}$ | 348 |
| Commissioning year | | 1981/82 / 1983/85 / 1987/88 |





## Project objectives

**Dried lignite fueled ignition and support firing system for steam generator F2 at Jänschwalde Power Plant**

**Potential**

**Max. load**

**Technical minimum load (minimum load without fuel oil support firing)**

**Minimum load with proposed measures**

**Measures**

- Increase in the effective control range of a 815 t/h steam generator at the Jänschwalde Power Plant by halving its technical minimum load from
  - currently 180 MW
  - to 90 MW.
- Prevention of grid-related shut-down and start-up processes and therefore avoidance of lifetime consumption and higher maintenance costs.
- Replacement of heavy fuel oil support firing by dried lignite.
- Increase in load gradients.



## LEAG Dry Lignite: Analytical Data

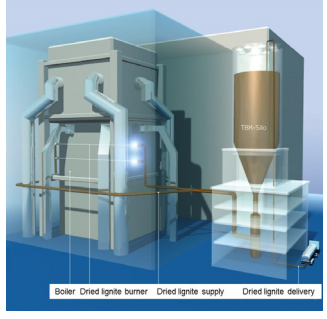
| | | |
|---|---|---|
| Grain: | | |
| Residue to 0.20 mm | in% | <13 |
| residue to 0.09 mm | in% | <40 |
| water | in % | 10 |
| ash | in % | 5 |
| Fl. ingredients | in % | 47 |
| sulfur | in % | 0.7 |
| calorific value | in GJ / t | 21 |

**Dry Lignite advantages:**

- Significant cost advantage over oil and gas
- Calculable price development
- Long-term security of supply
- High application comfort
- Comprehensive, competent service

## Dried lignite fuelled ignition and support firing system for steam generator F2 at Jänschwalde Power Plant

- Replacement of oil burners by 8 dried lignite burners
- One dosing tank supplies the 4 lignite burners on each level
- Each burner has a rotary weigh feeder, conveyor air blower, dust line, combustion air fan and ignition system (plasma ignition)
- The thermal output of each burner is infinitely variable between 7.5 and 30 MWth, controlled by the rotary weigh feeder
- CO2 inertization system, tank capacity 5.4 t, with liquid CO2
- Dried lignite – 21000 kJ/kg




Source: Vattenfall

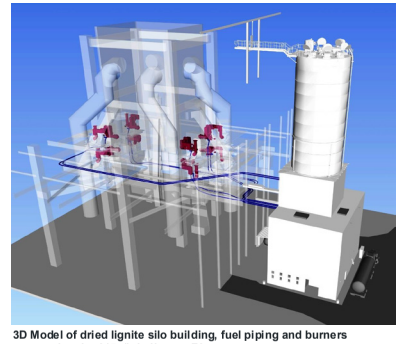




Special plasma burner for dried lignite



First fire



3D Model of dried lignite silo building, fuel piping and burners arranged at the 815 t/h boiler no. F2

Source: Vattenfall



## Agenda



Need for Flexibilisation

flexGen Jaenschwalde

**Moorburg Flexibilisation**

CCGT Leipzig

SMM-EMS Regulatory Area



## Moorburg Thermal Power Plant

| | | |
|---|---|---|
| **Construction period** | | 2008 – 2012 |
| **Continuous operation** | | 28.02. / 30.08.2015 |
| **Technical data:** | | |
| Live steam temperature | °C | 600 |
| Live steam pressure | bar | 276 |
| Reheat steam temp. | °C | 610 |
| Live steam delivery | kg/s | 574 |
| Preheating stages | | 9 |
| Feed-water temperature | °C | 293 |
| Exhaust steam pressure | mbar | 25 (abs.) |
| Generator output | MW | 2 x 827 |
| Net efficiency (condens. mode) | % | 46.5 |
| CHP efficiency: | % | 58 |
| Fuel | | bituminous coal (LHV: 26 MJ/kg) |
| Heat extraction | $MW_{th}$ | designed for 450, actual 30 |
| Commissioning year | | 2014 |



Source: Vattenfall

## MoorFlex - Reduction of technical minimum load

**Objective:**

- reduction from 35% (related to live steam quantity) to 26%
- plant operation must be ensured in pure coal operation, i.e. without additional oil firing or the use of auxiliary steam generators.

**Measures:**

- Control system adjustments
- Retrofit of automated NH4OH dosing of SCR DeNOx
- Reduction of the temperatures (live and RH) in the steam lines already during the shutdown process
- Adjustment of water-steam cycle diagram
- Adjustment of classification of emission data

➔ 9 minimum load tests have been undertaken
➔ 24% minimum load has been achieved, tests down to 20%
➔ Definition of new minimum load with OEM confirmation



## MoorFlex - Increasing load gradients & shortening start-up times

**Objective:**

- check possibilities for increasing the load gradients during load operation
- shortening the start-up and shutdown times

**Measures:**

- Electrical heating of thick-walled components (not realized)
- Optimization of the individual step chains and parallelization of sequences (50 minutes during the start-up process were saved)
- Optimization of starting fire performance
- Air-side bypass of mill air heat exchanger

➔ Definition and implementation of test programs
➔ Optimization of individual step chains and parallelization of sequences
➔ Shortened start up time warm-start by 30 min (104 to 78 min)
➔ 35% (49 to 32 t) fuel oil reduction achieved



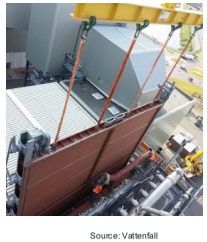
## MoorFlex - Expansion of warm start capability

**Objective:**

- Extend the warm start capability to a standstill period of > 48 hours to approx. 60 hours.

**Measures:**

- Installation of flue gas isolation valves with heated locking air system
- Installation of gas isolation valve at combustion air system with lock air system
- Pressure control with external steam load (not realized due to T24 material)
- Expansion of water level measurement bottle (not realized due to cost-benefit analysis)
- Retrofitting of automated butterfly valves at pulveriser locking air to avoid pressurizing the combustion chamber



Source: Vattenfall



## MoorFlex – online information




Source: Vattenfall

## Agenda



- About VPC
- flexGen Jaenschwalde
- Moorburg Flexibilisation
- **CCGT Leipzig**
- SMM-EMS Regulatory Area



## Efficiency increase and flexibilisation of CCGT Leipzig

**Client:** Municipal Utility of Leipzig city

**Project:**
Design engineering and implementation support during optimisation of the 172 MWe / 180 MWth CCGT CHP: modification of unit load control and heat cycle technology of the CHP Leipzig (2 x Siemens V64.3 each 65 MW + extraction backpressure turbine ENG 63/3 of 46 MW).

**Period:** 04/2012 – 12/2014

**Results:**
- Increasing operational flexibility
- Efficiency increase by 1.5% power / 3% overall
- Provision of +3.5 MW primary and +30 MW secondary control power

**VPC Services:**
- Feasibility Study
- Concept and basic design
- Detail design of all systems
- Interface coordination
- Site supervision and quality assurance
- Commissioning
- Operational plant documentation




Source: Vattenfall



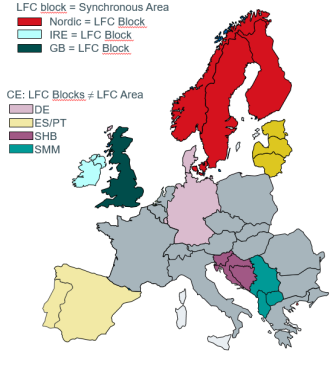
## Agenda



- About VPC
- flexGen Jaenschwalde
- Moorburg Flexibilisation
- CCGT Leipzig
- **SMM-EMS Regulatory Area**

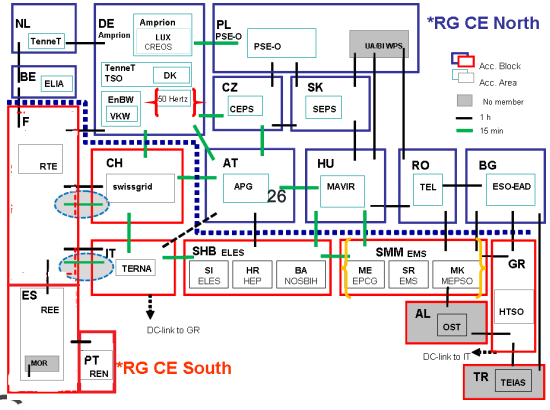


## Currently applied European synchronous areas/Load-frequency control (LFC)



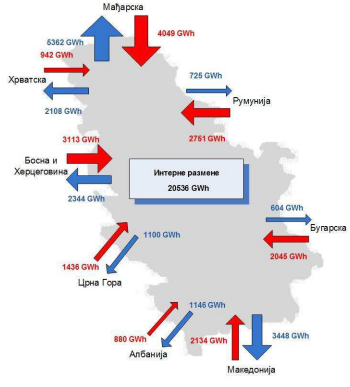

*Source: Commission Regulation (EU) Guideline on electricity transmission system operation*

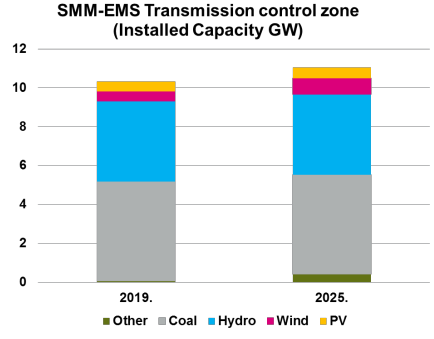
## Structure and organization of control blocks and regulatory areas in Europe






## The Serbian Power System




*Source: Technical Reports JP EPS*



## SMM-EMS Power System Characteristics

### Generation portfolio

| | Lignite | Hydro | Wind | Total |
|---|---|---|---|---|
| EP Serbia | 4200 | 2936 | 394 (5.2 %) | 7530 |
| EPCG | 225 | 649 | 72 (7.6 %) | 946 |
| ESM | 700 | 554 | 37 (2.9 %) | 1291 |
| Total | 5125 | 4139 | 503 (5.1 %) | 9767 |

### Available secondary reserve in Serbia

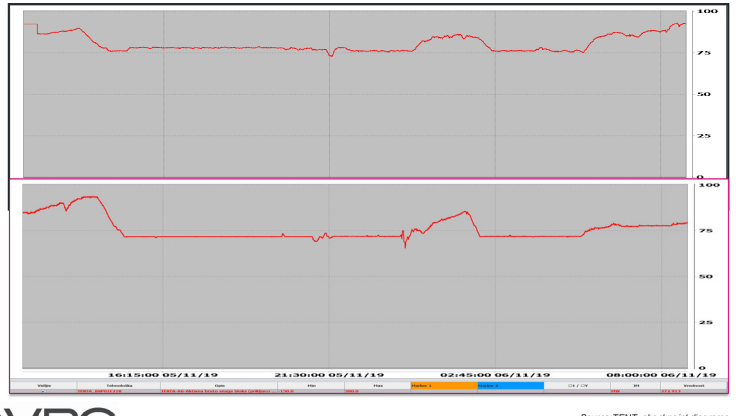
| Plant | HPP Djerdap | HPP Bajina Basta | HPP Bistrica | RHE Bajina Basta | TPP TENT A3-A6 | Total |
|---|---|---|---|---|---|---|
| Secondary Reserve | 6x90 MW | 4x35 MW | 2x28 MW | 2x70 MW | 2x45; 1x60; 1x 40; | 996 MW (14 %) |

- Prior to activation of the wind turbine, a reserve in the range of 150-200 MW (2.8 %) was contracted
- Upon entry into operation of the 394 MW wind turbine, it will be necessary reserve to contract >500 MW (requested 868 MW)

*Source: Technical Reports JP EPS*



## Share of TENT A units 329 MW and 347,5 MW in balancing wind turbines in Serbia (68 MW)




*Source TENT- checkpoint diagrams*

## Restrictions on thermal power plants for secondary regulation



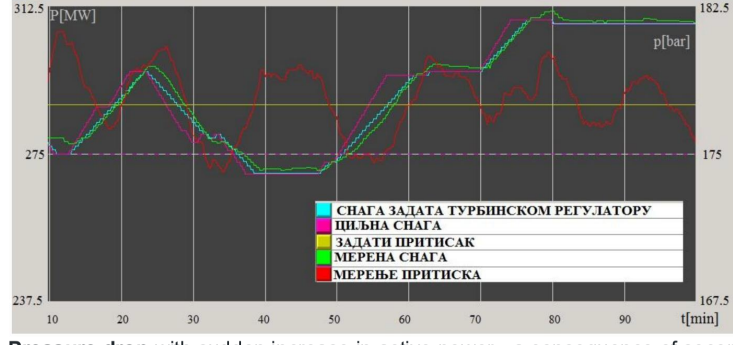
TENT A3-A6 plants Load change speed:
≤ 3 MW/min
(similar to Jaenschwalde before FlexGen)

Negative effects of cyclic load changes on the operation of thermal units:
- Live steam pressure
- Boiler thermal load

*Source TENT- checkpoint diagram*



## Restrictions on thermal power plants for secondary regulation



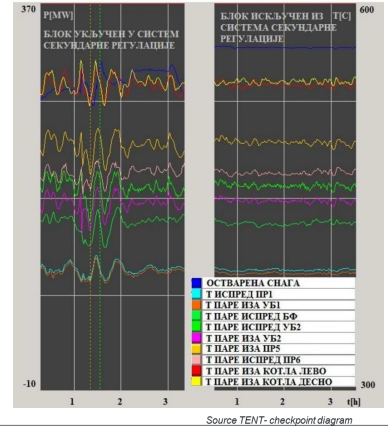

**Pressure drop** with sudden increase in active power - a consequence of secondary regulation.

*Source TENT- checkpoint diagram*



## Restrictions on thermal power plants for secondary regulation

- Comparison of steam temperatures in one line of a high-pressure superheater when the TENT A, 340 MW unit is switched on to the secondary control system and when the unit is not included in the secondary control system
- Material degradation processes due to cyclic loading: creep and fatigue
- Comprehensive calculation of the real costs of regulation that takes into account all the consequences for the equipment (mechanical, electrical and control) including *Equivalent Forced Outage Rate* – EFOR.




*Source TENT- checkpoint diagram*



## Conclusions

- The expansion of renewables into power systems, in addition to reducing the need for conventional (fossil) energy sources and the undoubted effects of environmental protection, imposes the need for efficient and rapid regulation of the system.
- The flexibility of old thermal power plants (especially those designed for base loads) requires a very careful and systematic approach. This implies:
  - Feasibility Study, Concept, Basic and Detail design of all Systems
  - Works Supervision, Commissioning, Operational plant Documentation etc.
- Key requirements for thermal power plants:
  Increasing number of start-up and shut down process, Speed of load change with a still high efficiency, Reduction of minimum load without fuel oil support, Shortening of start up time…

**VPC can reliably support you. German ("50Hertz Transmission") experience with balance of ~23GW Wind Turbines and PV with ~21GW Fossil Fuel Fired Power Plants is on our side.**

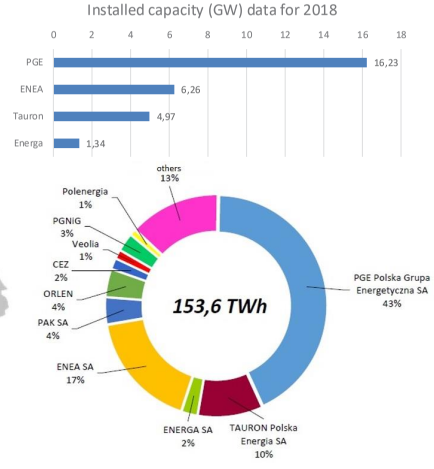
# Megatrends in the European energy sector and their impact on the transition of thermal power plants towards a sustainable model until 2050

**Grzegorz Kotte**
COO, VP for Power Generation
Technical Director of Kozienice Power Plant

**Sarajevo, 21st November 2019**

## Energy Sector in Poland




Source: Ministry of Energy and URE 2018



## Kozienice Power Plant

The Kozienice Power Plant is the largest hard coal-fired power plant in Poland. The plants key parameters are:

- Max. production capacity – ~ 20 [TWh]/year
- Installed power – 4 016 [MWe]
- Heating power – 266 [MWt]
- Base fuel – bituminous coal (hard coal)
- Hard coal consumption – 7 – 8 mln [t]/year

**LOCATION**

- The power plant stands next to some of the most valuable natural areas in Poland. It is surrounded by the Kozienice Landscape Park and The Central Vistula Valley – the area that constitute the European Natura 2000 Ecological Network.



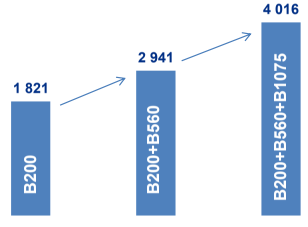


## Kozienice Power Plant

In December 2017, the power unit for supercritical parameters with a capacity of 1 075 MW gross was commissioned at the Kozienice Power Plant. The unit is one of the largest and the most efficient installations of this type in the world.

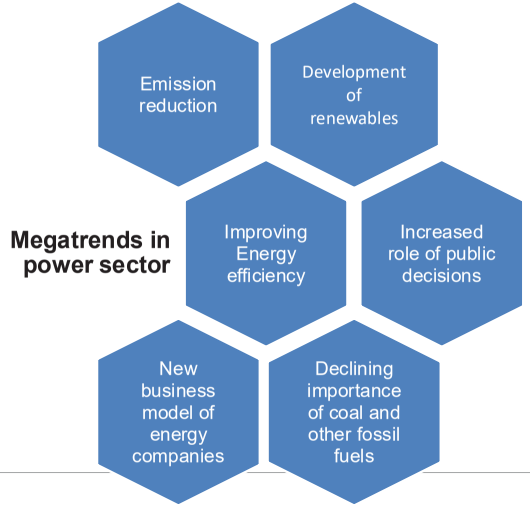


**Power increase of Kozienice Power Plant in the context of a series of units (MWe)**




| Units | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Installed power [MW] | 228 | 228 | 225 | 228 | 228 | 228 | 228 | 228 | 560 | 560 | 1 075 |
| Volltage [kV] | 220 | 110 | 220 | 220 | 220 | 110 | 220 | 220 | 400 | 400 | 400 |

## Power sector on the wave of megatrends






## Emission reduction

The basic task of installed environmental protection installations is to ensure continued operation of power units by complying with the emission standards set out in:

- LCP Directive No. 2001/80/EC of the EU Parliament, entered into force on 27 November 2001
- IED Directive No. 2010/75/UE of the EU Parliament from 24 November 2010 on industrial emissions, in force since 2016,
- BAT Conclusions of 17 August 2017 (which will be in force since August 17, 2021).

| LCP Directive 2001 | IED Directive 2010 | BAT Conclusions 2017 |
|---|---|---|
| • Installation of FGD I<br>• Installation of FGD II<br>• Modernization of 5 ESPs at Units No. 1, 2, 5, 6, 7 | • Installation of FGD III<br>• Installation of FGD IV<br>• Modernization of 4 ESPs at Units No. 3, 4, 8, 10<br>• Installation of SCR at Units 1 – 10 (excluding Unit No. 3) | • Modernization of 3 FGDs and 8 ESPs<br>• Expansion of continuous emission measurement systems<br>• Modernization of wastewater treatment systems from FGD |



## Three Questions We Have to Answer About Climate Change

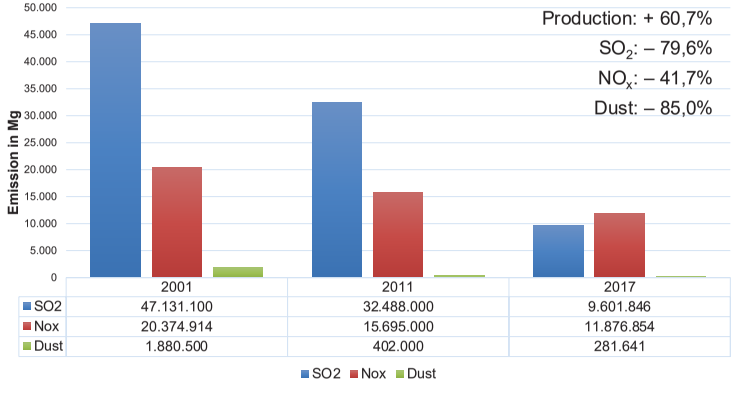
1. **MUST we change?**
2. **CAN we change?**
3. **WILL we change?**





## Emission reduction

**Air pollution emissions in Kozienice Power Plant 2001 – 2017**



## Emission reduction

| Parameter | Installations | Expenditure incurred in 2001 – 2017 [mln €] | Expenses to bear 2018 – 2021 [mln €] |
|---|---|---|---|
| $SO_2$ | Flue Gas Desulphurization Installations (FGD) | 257 | 5 |
| $NO_x$ | Flue Gas Denitrification Installations (SCR) | 93 | 35 |
| Dust | Electrostatic Precipitator (ESP) | 56 | 33 |
| Emission measurement | All stacks downstream of FGD | - | 1 |
| Other | HCl, HF, Mercury, Sewage from FGD | - | 3 |
| | **Total** | **406** | **77** |



FGD



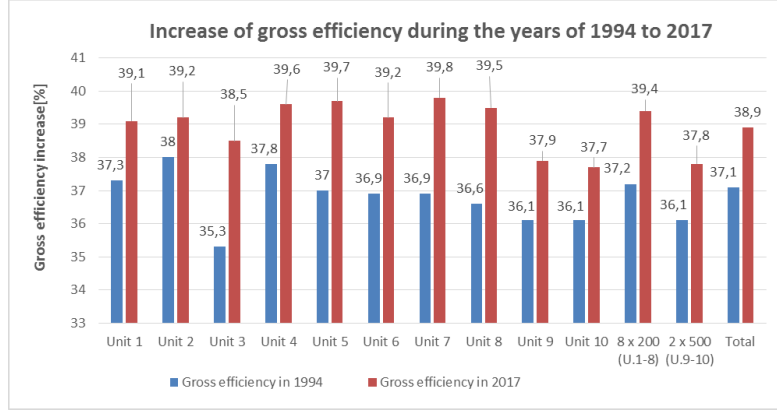
SCR



ESP



## Improving energy efficiency






## Improving energy efficiency

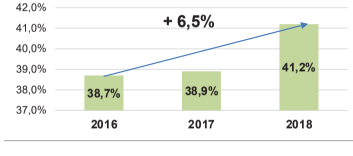
| No. | Technical parameters | Units 200 MW | Unit 1 075 MW |
|---|---|---|---|
| 1. | **Life-steam parameters** | | |
| | • Pressure | 127,5 bar | 242,5 bar |
| | • Temperature | 535 °C | 600 °C |
| | • Flow | 650 t/h | 2 894 t/h |
| 2. | **Efficiencies** | | |
| | • Efficiency gross of the unit | 39,4% | 45,6% |
| | • Efficiency net of the boiler | 92,3% | 95,0% |
| 3. | **Emissions** | | |
| | • $NO_x$ | ≤ 100 mg/Nm$^3$ | ≤ 100 mg/Nm$^3$ |
| | • $SO_x$ | ≤ 100 mg/Nm$^3$ | ≤ 100 mg/Nm$^3$ |
| | • Dust | ≤ 10 mg/Nm$^3$ | ≤ 10 mg/Nm$^3$ |
| | • $CO_2$ | 860 g/kWh | 740 g/kWh |



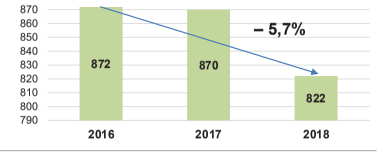
## Improving energy efficiency

| | Technical parameter | Unit | Unit No. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1. | Gross electricity generation efficiency | % | 1 – 10 | 38,7% | 38,9% | 39,2% |
| | | | 1 – 11 | - | - | 41,2% |
| 2. | Unit consumption of chemical energy of the fuel for gross electricity | kJ/kWh | 1 – 10 | 9 301 | 9 259 | 9 188 |
| | | | 1 – 11 | - | - | 8 736 |
| 3. | Gross electricity production | MWh | 1 – 10 | 13 770 055 | 12 853 581 | 11 291 279 |
| | | | 1 – 11 | - | - | 17 130 463 |
| 4. | Hard coal consumption (total) | Mg | 1 – 10 | 5 701 888 | 5 426 572 | 4 763 936 |
| | | | 1 – 11 | - | - | 6 886 727 |

**Gross electricity generation efficiency**



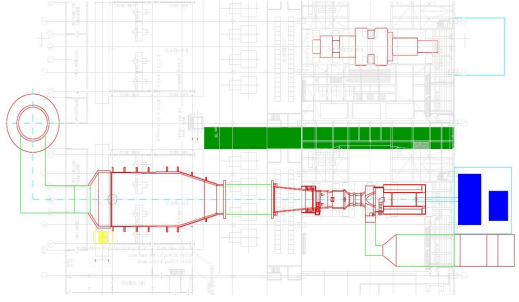

**$CO_2$ emission [g/kWh]**



## Declining role of coal and other fossil fuels / Emission reduction

Enea is carrying analyses to extend lifetime of Kozienice Power Plant operation with keeping existing output. In order to minimise CAPEX, usage the existing infrastructure is taken into consideration. The following solutions are analysed:

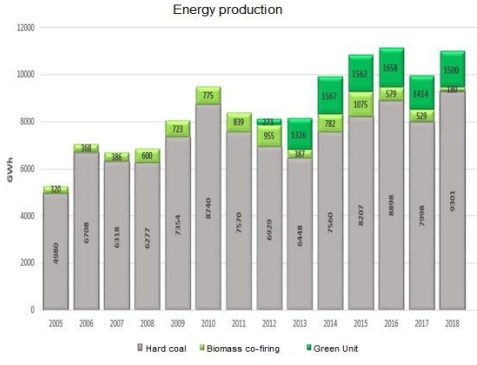
- Replacement of two existing 200 MW units with one 474 MW CCGT unit (gas turbine class F), expected efficiency > 57%,
- Replacement of three existing 200 MW units with one 650 – 700 MW CCGT unit (gas turbine class H), expected efficiency > 59%
- Emission: ≤ 350 g $CO_2$/kWh





## Declining role of coal and other fossil fuels / Emission reduction / Development of Renewables

Green Unit and Biomass co-firing in the existing 200 MW Units.




**GREEN UNIT (Biomass)**

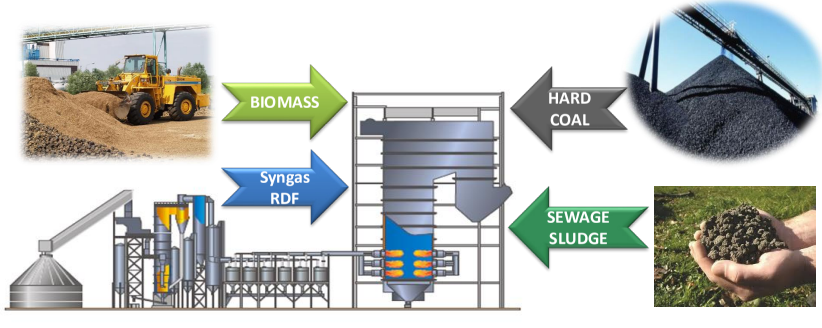
- Construction date: 2012
- Annual Energy Prod.: 1,5 TWh
- Net Electricity Capacity: 190 MW
- Efficiency: 39 %





## Declining role of coal and other fossil fuels / Emission reduction / Development of Renewables

Currently conceptual work is underway at Enea Połaniec Power Plant to obtain an answer regarding the possibility of using multi-fuel to generate energy on one of the 200 MW unit.




Project will meet emissions accordingly with EU's Clean Energy Package (under 550 g $CO_2$ / kWh)



## Declining role of coal and other fossil fuels / Emission reduction / Development of Renewables

IGCC is the cutting-edge technology, using coal resources as effectively as possible for power generation. Its demonstration successfully finished.

Two commercial projects have started in Japan with following parameters:

- Output: 540 MW gross / 480 MW net
- Plant efficiency: 48% net (LHV)
- Gas turbine type: 701 F4 (Mitsubishi)
- Emission: 630 g $CO_2$ / kWh (coal only)

The conceptual works are underway to build IGCC installation in Bogdanka Coal Mine with co-firing of biomass to reach emission level below 550 g $CO_2$/kWh.



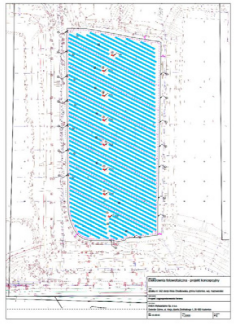
## New Business Model and Role of Traditional Energy Companies / Development of Renewables

### Renewable Energy Projects (2020 – 2025)

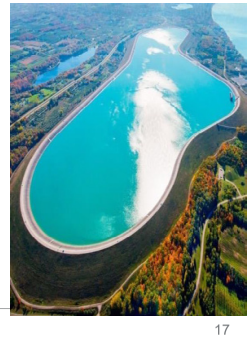
PV at the ash&sludge landfill of Kozienice Power Plant
- Power – ca. 8 MWe
- Area – 117 000 m²

PV for local communities (different locations)
- Power – ca. 100 MWe (1 – 40 MWe)
- Area – 1 460 000 m²

Pumping hydropower plant
- Power – 1 000 MWe
- Area – 1 520 000 m²



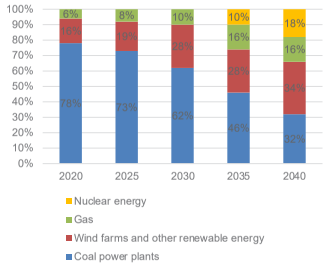


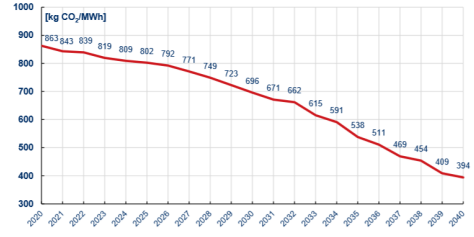




## Poland's development strategy according to the Polish Energy Policy 2040

### Forecast of sources of electricity production











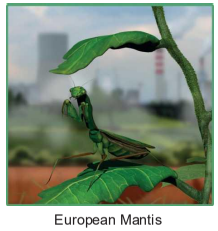

## Can „black" coordinate with „green"?



Small falcon at the „ash" landfill



Smooth snake – one of the rarest European snakes enlisted at IUCN Red List (*Coronella austriaca)*



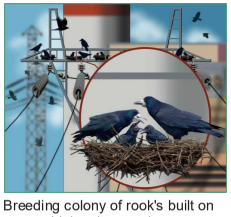
European Mantis *(Mantils religiosa)*



Sandcastle swallows on the landfill of ash and slag mixture



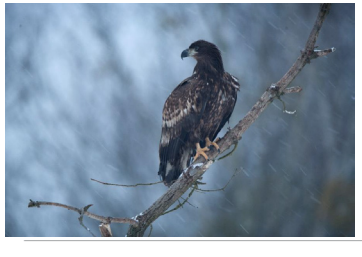
European beaver (*Castor fiber)*

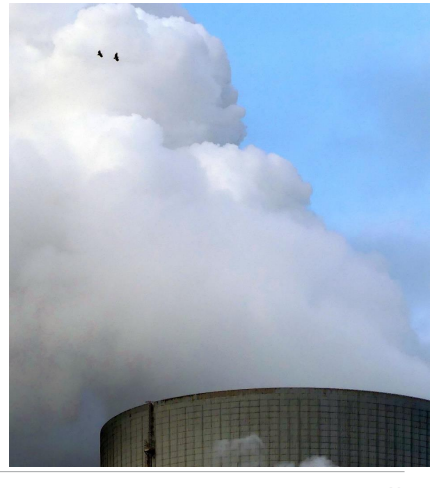


Breeding colony of rook's built on high voltage poles



## Courtship of white-tailed eagles above cooling tower, Kozienice Power Plant





CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

CPERI
Chemical Process and Energy Resources Institute

# Co-firing and biomass conversion experiences in Europe and the world

**Perspectives of Thermal Power in Bosnia and Herzegovina in Energy Transition**
**ANUBiH, Sarajevo, 21st November 2019**

**Emmanouil Karampinis*, Panagiotis Grammelis, Emmanuel Kakaras**
** Tel.:* +30 211 1069518, *Email :* karampinis (at) certh.gr

## Contents

- ✓ Definition of bioenergy retrofitting for fossil power plants
- ✓ Motivations for biomass co-firing / conversions
- ✓ Technology options
- ✓ Status of co-firing / conversions in the EU
- ✓ Policy issues and RED II
- ✓ Barriers & Opportunities
- ✓ Geographical Outlook
- ✓ The BIOFIT project case studies

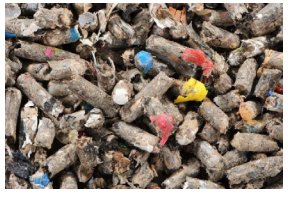
## Biomass co-firing & conversions

- ✓ **Co-firing** vs. **conversions**
- ✓ **Co-firing**: no rigorous / legal definition available
  - "*Co-firing is the simultaneous combustion of two or more fuels in the same plant in order to produce one or more energy carriers*" (Hansson et al., 2009)
  - "*Biomass co-firing consists of combusting biomass and fossil fuels, mostly coal but also natural gas, in the same power plant*" (ETSAP & IRENA Technology-Policy Brief E21, 2013)
  - "*Partial substitution of coal as a main fuel in a utility boiler with biomass or waste*" (IEA Bioenergy Task 32) – does not include cases where coal is partially substituting biomass
  - Not strictly defined: Same plant / unit / boiler? Fuel mixture ratio? Hours of co-firing operation per year?
- ✓ **Conversions**: no rigorous / legal definition available
  - main fuel (usually coal) fully substituted by biomass in a boiler

## Motivation: opportunity fuels

Waste wood, RDF / SRF, exhausted olive cake (occasionally) and others can be cheaper than coal





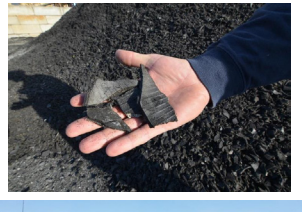




Image sources:
- Waste wood / ENDS Waste & Bioenergy
- Tire Derived Fuel (TDF): East Kentucky Power Cooperative
- Subcoal® RDF / SRF pellets / N+P Group BV - N+P RECYCLING BV - N+P International BV
- Olive cake / OLIVKETTS Global Energy Ltd.

# Motivation: $CO_2$ prices and limits

**Emissions Trading Scheme (ETS)**

Carbon price development since 2008




**Capacity Markets**

- ✓ Exclusion from capacity reserve mechanisms of facilities that generate more than
  - 550 $gCO_2$ of fossil fuel origin per kWh of electricity
  - 350 kg $CO_2$ of fossil fuel origin on average per year per installed kWe

# Motivation: support mechanisms

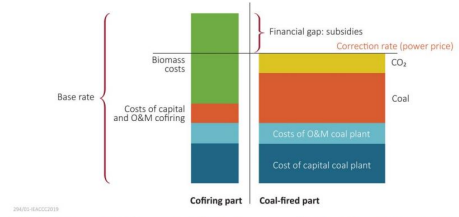



Figure 1 Illustration of the Netherlands SDE+ calculation method for cofiring biomass at a coal-fired power plant (Lensink and Cleijne, 2017)

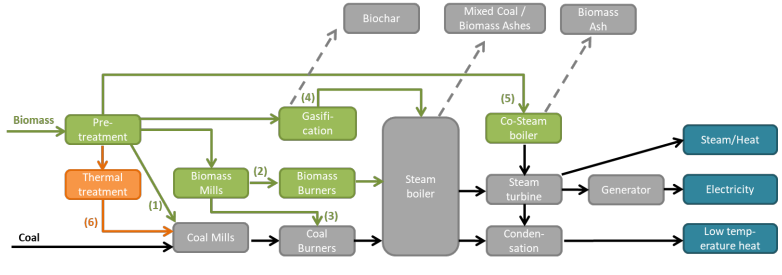
- ✓ Feed-in tariffs / premiums
  - Japan
  - UK / CfD
  - Netherlands / SDE+
- ✓ Renewable portfolio standards / Green Certificates
  - UK / ROCs scheme
  - South Korea
  - Poland

TABLE 2 DUTCH SDE+ SUBSIDIES FOR 2017 (LENSINK AND CLEIJNE, 2017)

| Parameters | Existing capacity | New capacity |
|---|---|---|
| Base rate, €/kWh | 0.108 | 0.111 |
| Base price, €/kW | 0.031 | 0.031 |
| Weighted number of full load hours, h/y | 5839 | – |
| Provisional correction rate, €/kWh | 0.032 | 0.032 |

Source: Zhang X. (2019), Support mechanisms for cofiring biomass with coal (IEE CCC Report 294)

# Overview of technology options




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(1) Direct co-firing/co-milling
(2) Direct co-firing/separate milling
(3) Direct co-firing/separate burners
(4) Indirect/gasification co-firing
(5) Parallel co-firing
(6) Thermal treatment of biomass

- CHP steam power process
- Retrofit fuel
- Retrofit installation
- Products
- By-products

# Direct co-firing

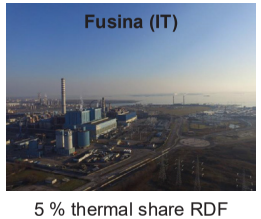
- ✓ Description: Biomass and coal combusted in the same furnace, using same or different mills and burners as appropriate
- ✓ Co-firing fuel: Woody biomass, herbaceous & forest residues, RDF / SRF, exhausted olive cake, etc.
- ✓ Typical biomass share: up to 20 % fuel input for wood, usually lower for agrobiomass / RDF
- ✓ # industrial references: > 100 (http://task32.ieabioenergy.com/database-biomass-cofiring-initiatives/)
- ⊕ Easy to implement, low cost, facility can easily switch back to coal-firing if no biomass available
- ⊖ Limited substitution rate, mixing of ashes, continued reliance on coal




10 % thermal share various biomass (forest, agro, food industry, energy crops)




10 % thermal share straw (from 2016, conversion to 100 % wood pellets)




5 % thermal share RDF

## Indirect (gasification) co-firing

- ✓ Description: Biomass gasifier to produce syngas, combustion of syngas in coal boiler
- ✓ Co-firing fuel: Wide range, including “difficult” fuels such as wood waste, waste fractions, etc.
- ✓ Typical biomass share: up to 40 % of fuel input
- ✓ # industrial references: ~ 5
- ⊕ No mixing of ashes, utilization of “difficult” fuels possible, less strict requirements for quality of syngas compared to dedicated gasification
- ⊖ Higher cost (installation of new gasifier)




Waste wood 83 $MW_{th}$ (5% of fuel input)




Recycled energy fuel (REF), sawdust, bark, wood chips, wood wastes 45-70 $MW_{th}$ (15% of fuel input)

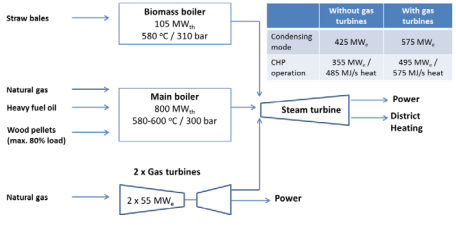



Forest residues 140 $MW_{th}$ (up to 40 % fuel input)

## Parallel co-firing

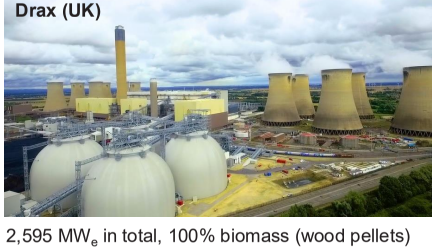
- ✓ Description: Separate biomass boiler, coupled with coal boiler on steam side
- ✓ Co-firing fuel: Wide range, including difficult fuels such as straw
- ✓ Typical biomass share: N/A
- ✓ # industrial references: ~ 5
- ⊕ No mixing of ashes, utilization of “difficult” fuels, higher efficiency than stand-along biomass
- ⊖ Higher cost (but not as high as stand-alone biomass power plant)




## Biomass conversions

- ✓ Description: complete retrofit of coal boiler / mills to accommodate very high shares of biomass co-firing
- ✓ (Co-)firing fuel: wood pellets (white), wood chips (rarely)
- ✓ Typical biomass thermal share: up to 100 %
- ✓ # industrial references: > 15
- ⊕ Equivalence with dedicated bioenergy installations, complete coal phase-out
- ⊖ Handling of large biomass volumes, safety issues, operation in CHP mode is rare




2,595 $MW_e$ in total, 100% biomass (wood pellets)



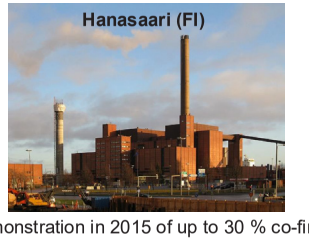

125 $MW_e$, 100% biomass (wood pellets)

## Thermally treated biomass

- ✓ Description: thermally treated biomass is used to directly substitute coal
- ✓ Co-firing fuel: Thermally treated (torrefied, steam exploded, etc.) wood pellets
- ✓ Typical biomass share: up to 100 %
- ✓ # industrial references: 1 commercial case (Thunder Bay Unit 3), several demonstrations
- ⊕ Minimum plant retrofitting / investment required, handling of biomass similar to coal
- ⊖ Thermally treated biomass market still in development

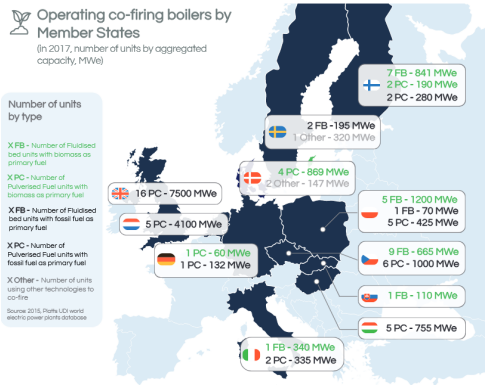



First 100 % retrofit to Arbaflame (steam exploded) wood pellets. Commercial operation in 2015. Retrofit cost ~ 30 €/$kW_e$

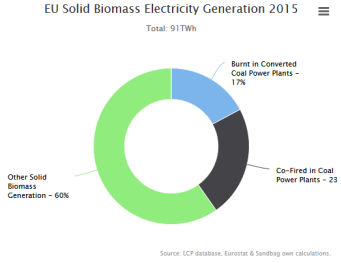



Demonstration in 2015 of up to 30 % co-firing of Blackwood torrefied wood pellets

## Status of co-firing / retrofits in EU




Source: Bioenergy Europe (2018) Co-firing: clarifying a concept Factsheet




Source: Sandbag (2017)

Co-firing: PO, FI, DK, CZ, HU over 88% of the co-fired biomass in 2015

Conversions: primarily in UK, BE, DK

**Country situations are also an outcome of major differences in national policies.**

## RED II: impact on co-firing / retrofits

**Directive (EU) 2018/2001 – "RED II"**

- ✓ Bioenergy can a) be accounted towards the overall RES-target and sectorial sub-targets, b) be eligible for public financial support
- ✓ Biomass is carbon neutral for ETS only if compliant with sustainability criteria
- ✓ Specific sustainability criteria for different types of biomass
- ✓ Specific requirements for electricity-only installations
  - No use of fossil fuels as "main fuels" (acceptable share not clarified yet)
  - No cost-effective potential for highly efficient CHP (Article 14 of Directive 2012/27/EU)
  - Requirements based on size (fuel input)
    - < 50 MW: no additional requirements
    - 50 – 100 MW: Best-available technology associated energy efficiency levels or use Biomass CCS
    - > 100 MW: Electrical efficiency of 36 % or applying Biomass CCS
- ✓ GHG emissions saving criteria
  - > 70 % for installations starting operation after 1 January 2021
  - > 80 % for installations starting operation after 1 January 2026
- ✓ Member states can apply stricter sustainability criteria or higher energy efficiency requirements

## Barriers & Opportunities

**Barriers / Challenges**

- ✓ Appropriate policy framework required
- ✓ Mobilization of huge biomass volumes
  - Sourcing (e.g. involvement of producers)
  - Infrastructure (especially for thermally treated biomass)
  - Sustainability issues
  - Public opposition
- ✓ Technical limitations under RED II (efficiency)

**Opportunities**

- ✓ Coal phase-out
  - Several members states & utilities plan to be coal-free before 2030
  - Utilization of capital assets (coal power plants) that would otherwise have to be abandoned
- ✓ Non-stochastic renewable or low-carbon back-up plants needed to stabilize an electricity grid with high shares of intermittent RES (wind, solar)
- ✓ Towards harmonized EU framework with RED II

## Geographical Outlook

**European Union**

- ✓ Both co-firing and conversions are well-established technologies
- ✓ Co-firing is expected to subside in the long run due to RED II and coal phase-outs
- ✓ New projects focusing on conversions; support scheme is required and needs to be justified and proven
- ✓ Biomass conversions as part of the strategy for Coal Regions in Transition?
- ✓ New biomass sourcing options (e.g. agrobiomass) investigated

**Western Balkans & Turkey**

- ✓ Coal power is expected to remain important in the electricity mix
- ✓ To our knowledge, no commercial co-firing experience at the moment (only demonstrations)
- ✓ Co-firing as a short-term solution to reduce GHG emissions can be developed
- ✓ Retrofits more challenging, more complicated fuel sourcing due to inland coal plant location

**Res of the world**

- ✓ Co-firing with opportunities fuels is already deployed in several cases
- ✓ Interest and projects with in high co-firing shares or conversions in some industrialized Asian countries (e.g. Japan, South Korea, China) thanks to favorable policies

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# Biomass co-firing & conversion case studies

JP ELEKTROPRIVREDA BIH d.d. - Sarajevo

- ✓ Elektropriveda BiH / Tuzla power plant Unit 6 (215 $MW_e$)
  - Up to 30 % (mass basis) co-firing with local biomass sources (sawdust, agricultural residues)
- ✓ Elektropriveda BiH / Kanakj CHP plant Unit 5 (118 $MW_e$)
  - 100 % biomass conversion





EP PRODUZIONE

- ✓ EP Produzione / Fiume Santo power plant Unit 4 (320 $MW_e$) in Sardinia
  - 100 % biomass conversion



The BIOFIT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817999. The sole responsibility for the content of this presentation lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the INEA nor the European Commission are responsible for any use that may be made of the information contained therein.

# PRODUŽENJE RADNOG VIJEKA TE

## REVITALIZACIJA, POVEĆANJE SNAGE, POBOLJŠANJE EFIKASNOSTI

*Dijagnostika:*
- Monitoring, mjerenja, kompjuterske simulacije

*Rješenja:*
- Nove metode uklanjanja naslaga, …

Nijaz Delalić, Zdravko Milovanović, Dušan Golubović, Izet Smajević

## *1. Uvod*

Pad pouzdanosti, efikasnosti i raspoloživosti postrojenja, te posljedično povećano ugrožavanje okoliša tokom dugotrajnog pogona, zahtijeva u određenom periodu radikalnu modernizaciju energetskog bloka, uključivo i revitalizaciju njegovih komponenti koje ostaju u pogonu

Odluka o revitalizaciji postojećeg ili izgradnji novog energetskog bloka proističe iz rezultata Studije izvodivosti, u okviru koje se porede ekonomski, okolinski i socijalni parametri ova dva zahvata

Metode za procjenu preostalog životnog vijeka postrojenja se baziraju na zahtjevnim procedurama, koje podrazumijevaju poznavanje historije pogona, kao i ispitivanje osobina materijala komponenti bloka

## *2. Procjena stanja i preostalog radnog vijeka termoelektrane*

Polazeći od podataka o ugrađenim materijalima, kao i konstrukciji, dimenzijama, te projektnim i radnim parametrima ogrjevnih površina, neophodno je izvršiti analizu svih prethodnih otkaza, vodeći strogo računa o mogućim uzrocima tih otkaza

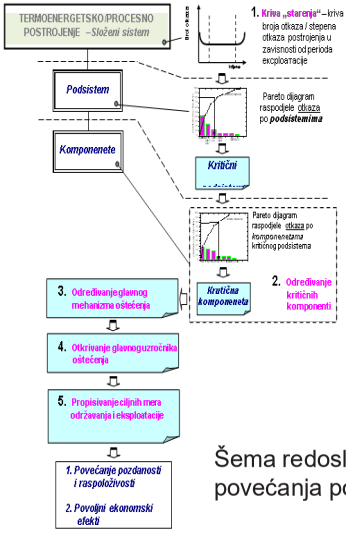
Derogiranje cijevnog sistema kotlovskih postrojenja, u načelu, se zasniva na 22 osnovna mehananizma, Tabela 1.

Rezultati istraživanja u TE Ugljevik su pokazali da osnovne uzročnike oštećenja kotlovskih cijevi čine sljedeći mehanizmi: erozija letećim pepelom, korozija, visikotemperaturno puzanje, kratkotrajno pregrijavanje, erozija mlazom iz duvača gara, korozija plamene strane isparivača, deformacije i erozija usljed pada šljake, zamor materijala ...

Tabela 1. Osnovni mehanizmi oštećenja kotlovskih cijevi, izvod

| Mehanizam oštećenja | | Mogući uzročnik |
|---|---|---|
| Oštećenje usljed napona | - kratkotrajno pregrijavanje;<br>- zavari raznorodnih materijala; | Održavanje i predistorija kotla (projekat kotla, proizvodnja opreme, režim eksploatacije i sl.) |
| | - visokotemperaturno puzanje | Pogonski režim vodeno-parne struje |
| Korozija vodene strane | - kaustična korozija;<br>- naponsko-korozione pukotine; | Hemijski režim vodeno-parne struje |
| | - vodonično oštećenje/korozija;<br>- Piting (lokalna korozija) | Održavanje i predistorija kotla (projekat kotla, proizvodnja opreme, režim eksploatacije i sl.) i hemijski režim vodeno-parne struje |
| Erozija | - erozija pepelom;<br>- erozija usljed mlaza iz duvača gara; | Održavanje i predistorija kotla (projekat kotla, proizvodnja opreme, režim eksploatacije i sl.) |
| | | |
| | - i drugo | |

## Procjena preostalog radnog vijeka termoelektrane




Primjer: RiTE Ugljevik I (300 MWe)

Ocjena zatečenog stanja i prognoza ponašanja složenog sistema termo-elektrane je najpogodnija analizom toka otkaza u funkciji trajanja pogona

Analiza toka otkaza, kako je pokazano krivom 1. na slici, treba da pokaže trend „starenja“ postrojenja. Analizom učestalosti otkaza, vremena trajanja zastoja i ekonomskih pokazatelja, određuje se pravac aktivnosti na podizanju kvaliteta bloka

Šema redoslijeda aktivnosti na razradi programa za povećanja pouzdanosti i raspoloživosti postrojenja

## Zamjenski blok TE Gacko II (1x350 MWe)

Izgradnjm zamjenskog bloka TE Gacko II, koja je značajna kapitalna investicija u regionu će:

-zadovoljit javni interes šire društvene zajednice, i postići kontinuitet u proizvodnji električne energije na tom području,

-omogućiti dugoročno daljinsko grijanja grada i prigradskih naselja,

Toplotna snaga sistema za grijanje TE i grada je max. 55 MWt, dužina primarnog cjevovoda za grijanja grada je oko 4 km, temperatura vode u primarnom cjevovodu je 130/70 °C.

Predviđena godišnja proizvodnja električne energije za 7304 časova rada iznosi 2556.4 GWh bruto, i to će se pozitivno odraziti na privredu i ekonomiju RS i BiH u cjelini.

Na kompleksu TE Gacko je većina pomoćnih objekata u startu izgrađena na duple kapacitete, te će služiti i za potrebe TE Gacko II.



Dio zajedničkih pogona i postrojenja za TE Gacko I i TE Gacko II

## *3. Garantna i normativna ispitivanja termoenergetskih blokova*

Svaka primopredaja novoizgrađenog ili revitalizovang termoenergetskog postrojenja zahtijeva izvođenje garantnih ili normativnih ispitivanja, s ciljem utvrđivanja dostignutih vrijednosti pogonskih parametara.

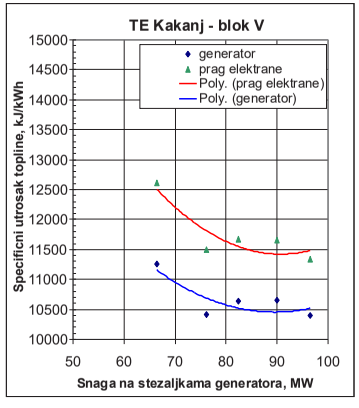
Normativna ispitivanja se izvode periodično i mogu ih vršiti samo ovlaštene vanjske profesionalne insitucije. Rezultati koji se dobijaju omogućavaju formiranje slike o tehničko-tehnološkom stanju postrojenja prije i poslije remonta, odnosno o postignutom benefitu.

Odgovarajućim standardima su propisani način mjerenja i parametri koji se mjere, kao naprimjer:

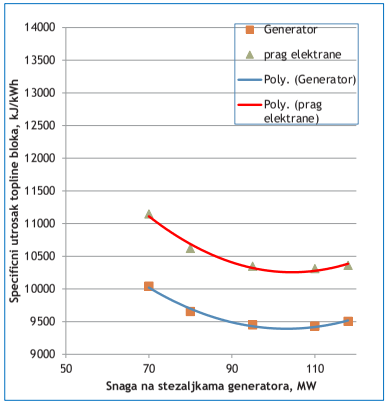
- parametri stanja i maseni protok proizvedene pare,
- vlastita potrošnja pomoćnih postrojenja,
- stepen korisnosti kotla, turbinskog ciklusa i ciklusa u cjelini; gubici,
- padovi pritiska i protoci u toku radnog medija, vazduha i d. plinova,
- temperatura i protok rashladne vode, i drugo...

## TE Kakanj
## Blok 5, Normativ potrošnje bloka

prije revitalizacije i modernizacije

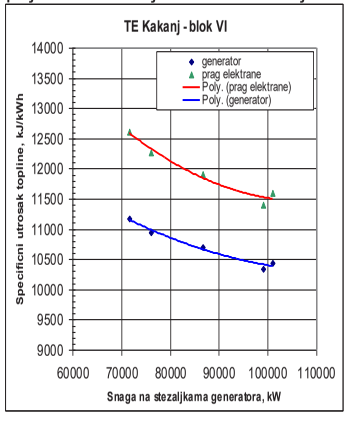



poslije revitalizacije i modernizacije

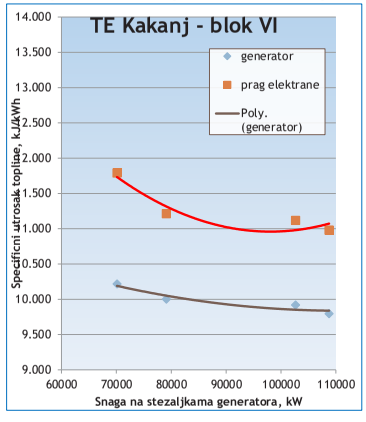



## TE Kakanj
## Blok 6, Normativ potrošnje bloka

prije revitalizacije i modernizacije

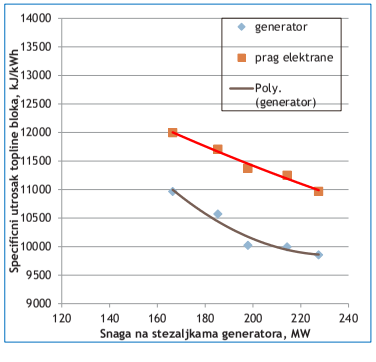



poslije revitalizacije i modernizacije

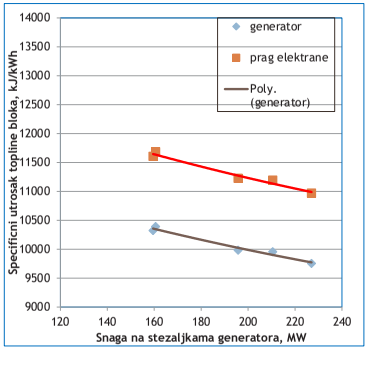



## TE Kakanj
## Blok 7, Normativ potrošnje bloka

prije djelimične rekonstrukcije




poslije djelimične rekonstrukcije




## *4. Kompjuterska simulacija procesa u TE*

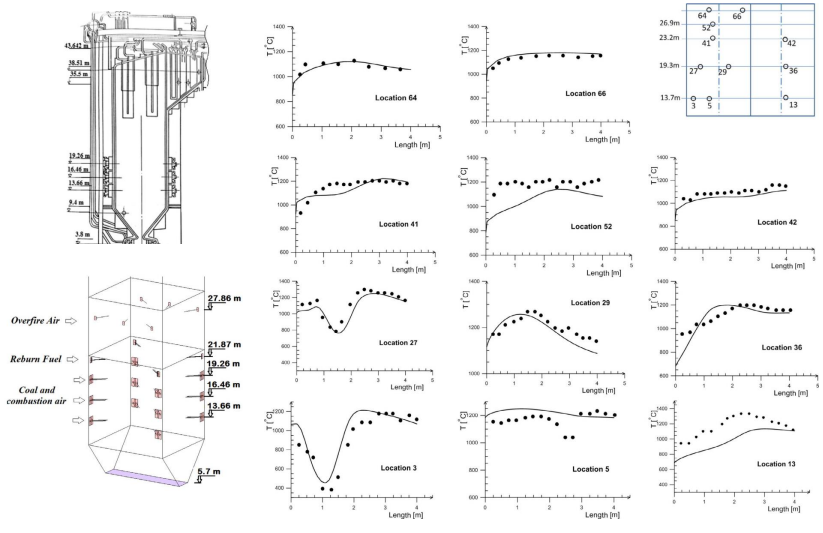
Kompjuterska simulacija je eksperimentu komplementarna naučno-istraživačka i razvojna metoda.

Značajno je jeftinija i komfornija od eksperimenta.

Metoda je validna ako je verificirana na odgovarajućem testnom eksperimentu.

Validirana metoda komjuterske simulacije često omogućava uvid i u detalje procesa čije parametre je teško, ili čak nemoguće tačno izmjeriti.

## Eksperimentalna validacija kompjuterske simulacije:
Temperature u ložištu kotla 500 MWt (*Chernetskiy et al 2018*)




## *5. Inovativne tehnologije za povećanje energijske efikasnosti i snage*

### Detonaciono-impulsni postupak čišćenja ogrijevnih površina u pogonu kotla

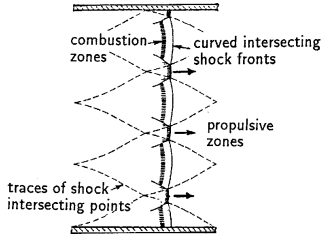
Klasična metoda čišćenja, puhanje parom:

- lokalno čišćenje
- erozija zidova cijevi
- učestalo pucanje cijevi
- učestali zastoji bloka
- porast troškova održavanja
- pad raspoloživosti bloka



Puhanje parom: erodirane zone i tragovi mlazeva pare na cijevima

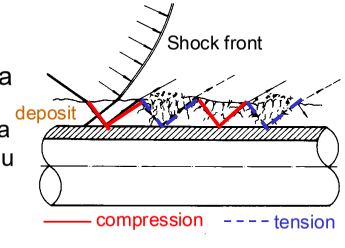
## Detonacioni i udarni talas - osnove




Generisanje i struktura detonacionog fronta

- udarni talasi se generišu paljenjem homogenizirane smješe gorivo-oksidant u cijevi izvan kotla

Šema djelovanja talasa na lomljenje i uklanjanje depozita

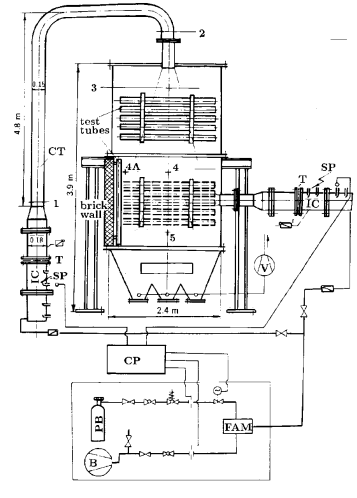



- udarni talas prodire kroz depozit i odbija se od površinu cijevi smjenjujući se zatim u depozitu kao kompresioni i ekspanzioni

Depozit razara ekspanzioni talas

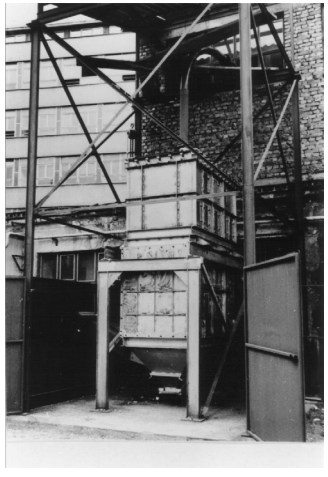
## Laboratorijsko istraživanje, MFSa 1981-1985.
u saradnji: EPBiH/TE Kakanj, MF Sarajevo, SIZ za nauku SR BiH

Šematski prikaz laboratorijske linije

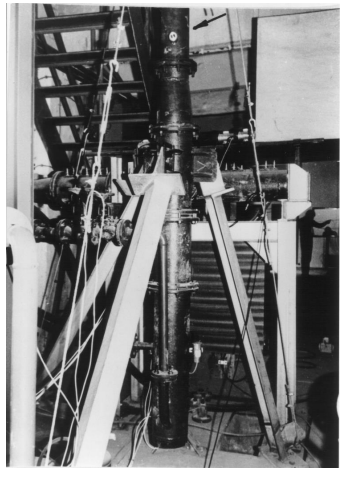



| | |
|---|---|
| B | Puhaljka |
| CP | Kontrolni panel |
| CT | Spojna udarna cijev |
| FAM | Mješač goriva i zraka |
| IC | Detonaciona komora |
| PB | Propanbutan boca |
| SP | Svjećice |
| T | Turbulizator |
| V | Isisni ventilator |
| 1-5 | Davač pritiska |

## Laboratorijsko istraživanje, MFSa 1981-1985.

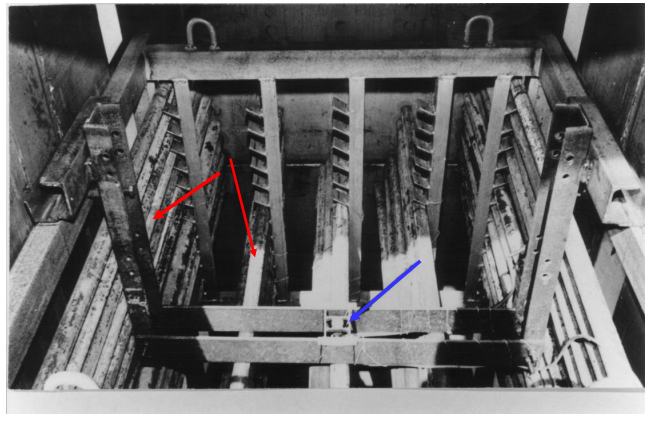


Eksperimentalni model kotla



Detonacione komore

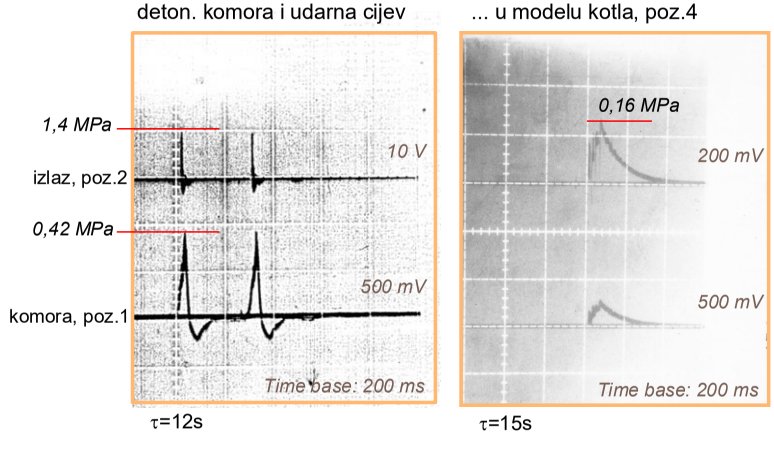
## Unutrašnjost modela kotla



→ paket pregrijačkih cijevi iz TE Kakanj sa originalnim naslagama iz pogona

→ piezoelektrični davač pritiska

## Oscilogram talasa, pozicije 1, 2 i 4-model kotla

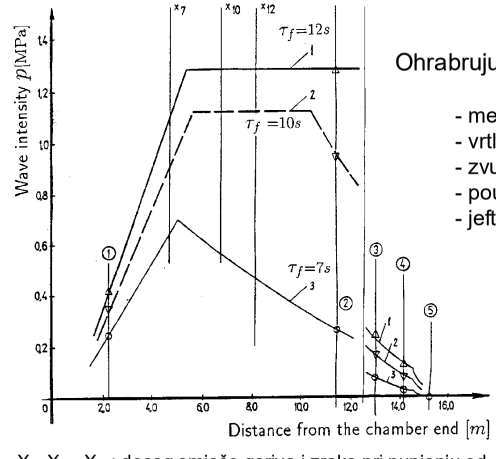



τ=12s τ=15s

Paljenje najdonjom svjećicom

τ - vrijeme punjenja sistema gorivom [s]

## Intenzitet talasa u detonacionoj komori i modelu kotla



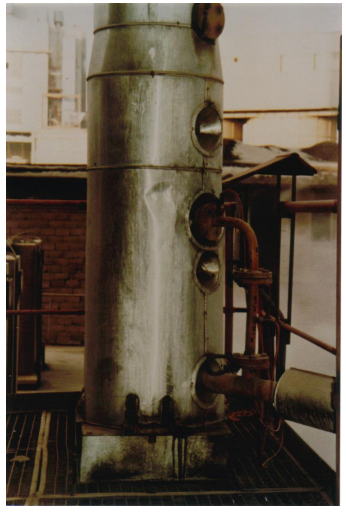

Ohrabrujući laboratorijski rezultati

- mehanička energija
- vrtloženje
- zvuk ⇒ *čišćenje cijelog kotla*
- pouzdano
- jeftino

**patentirano**
testiranje u pogonu

$X_7$, $X_{10}$, $X_{12}$: doseg smješe goriva i zraka pri punjenju od τ = 7, 10 i 12 s

## Testiranje i pogon u TE Kakanj

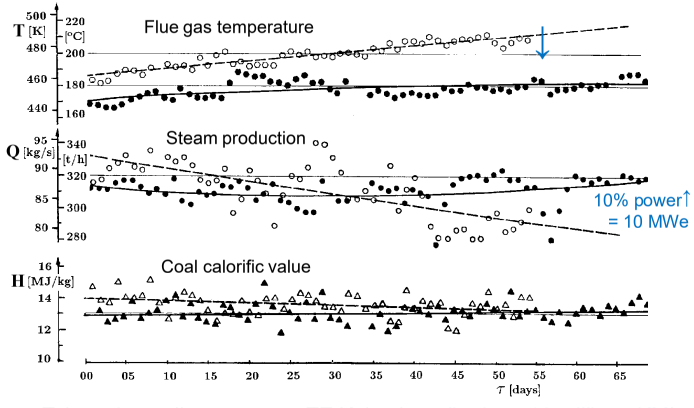


Detonaciona komora instalirana na bloku V, TE Kakanj

U TE Kakanj je na dva kotla (2x360 MWt) instalirano ukupno pet ovakvih komora

## Testiranje detonaciono-impulsnog čišćenja u pogonu

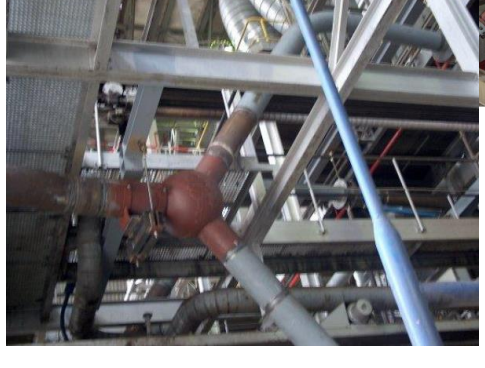
Prazni simboli: 18 parnih puhača gara, bez deton-impulsnog čišćenja (55 dana)
Puni simboli: deton-impulsno čišćenje + 6 puhača gara (70 dana)




Tokom 27 *godina* pogona u TE Kakanj: - ušteđeno 60 milliona KM!
- $10^6$ t $CO_2$ manje u atmosferi!

## ... izvan Bosne i Hercegovine

Kotao u Njemačkoj, produkcija pregrijane pare 980 t/h





Detonacione komore 1 i 2

Detalj: račva spojne udarne cijevi

## Interes za ovo tehničko rješenje su pokazali

2002, SAD: Pratt & Whitney, Aeroscience Lab, Seattle
2003, Njemačka: Kotao na ugalj/ Termoblok, 980 t/h pregrijane pare
2004, Italija: RUTHS-termička obrada otpada, Filago/ Bergamo, Lombardy
2005, Grčka: TE Kardia 1250 MW, Public Pow. Corp (DEH), West Macedonia
2009, Kina... i drugi

*BiH*: 1984. EPBiH/ TE Kakanj – implementirano na 2 bloka!, 27 godina u pogonu!
1986. Čeličana II RMK Zenica, 1992. INCEL Banja Luka





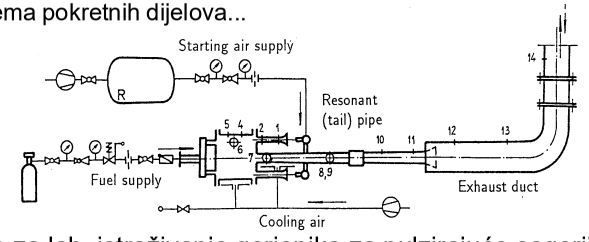
Termička obrada komunalnog otpada - Filago, Italija 2004. g.

## *6. Sljedeća faza razvoja ...*

### Gorionik za pulzirajuće sagorijevanje gasovitog goriva i sprašenog uglja

Malootpadna tehnologija sagorijevanja DC IX: Vlada RBiH i TE Kakanj

- poboljšano sagorijevanje i prenos toplote
- učestalo gašenje: smanjuje srednju temperaturu sagorijevanja
- manja emisija NOx i povoljni uslovi za manju emisiju SOx
- nema pokretnih dijelova...




Linija za lab. istraživanje gorionika za pulzirajuće sagorijevanje
Šematski prikaz, MF Sarajevo, 1988-2008.*

* sa prekidom 1992-1998.

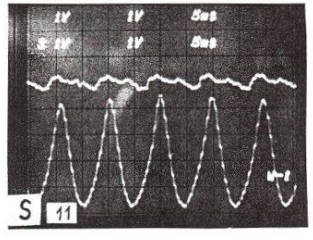
## Gasni pulzirajući gorionik: eksperiment, MFSa




Gorionik

- vlastita konstrukcija
- bez pokretnih dijelova
- f: 80-180 Hz
- $\Delta p_k$: do 100 kPa

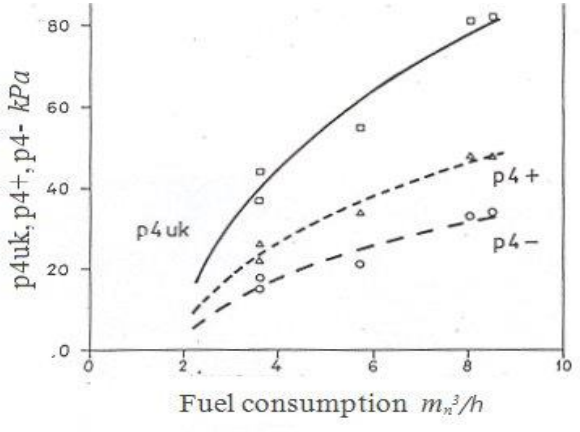
f - učestalost paljenja
$\Delta p_k$ - oscilacije pritiska u komori




Osciloskop: snimak pulzirajućeg pritiska
dole: komora za sagorijevanje, gore: rezonantna cijev

I. Smajević, Istraživanje pulzirajućeg sagorijevanja gasovitog goriva sa analizom mogućnosti primjene, doktorska disertacija, Mašinski fakultet Sarajevo, 1991.
I. Smajević, K. Hanjalić, 1995, A computational model of an aerodynamically-valved Helmholtz-type pulse combustor. In: K. Hanjalić and J. M. Kim (Eds), Proc. 2nd Int. Forum on Expert Systems and Computer Simulation in Energy Engineering (Erlangen, Germany, 1992), Begell House Inc., New York, Wallingford, ISBN 1-56700-031-02, 316-321

## Rezultati istraživanja pulzirajućeg sagorijevanja, izvod

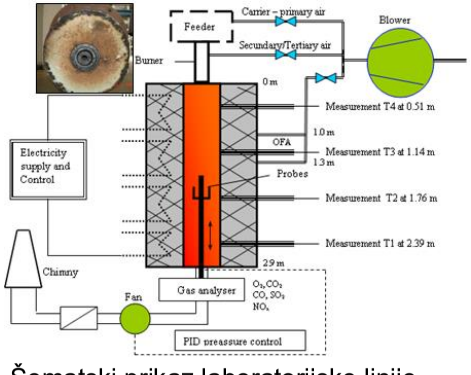



Pozitivna (p4+), negativna (p4-) i ukupna (p4uk) amplituda pritiska u komori za sagorijevanje

## *7. Kosagorijevanja bh uglja i biomase*

### preduslov za unaprjeđenje tehnologije sagorijevanja u TE BiH

### Istraživanje u laboratoriji*, MF Sarajevo, 1988-2016.



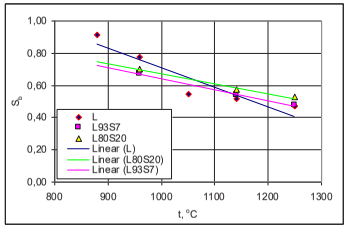

Šematski prikaz laboratorijske linije

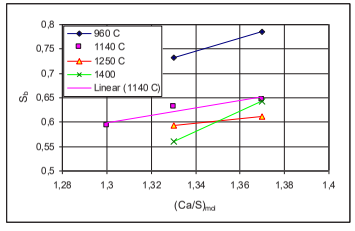


20 kW PF ispitno ložište
detalj iz laboratorije

*uz fin. podršku RMU Kakanj, TE Kakanj, Vlade SR Njemačke, vlada KS i FBiH, Vijeća ministara BiH

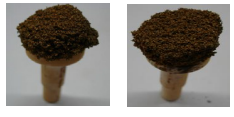
## Izbor iz rezultata lab. istraživanja kosagorijevanja




Stepen vezivanja sumpora za mineralnu komponentu goriva





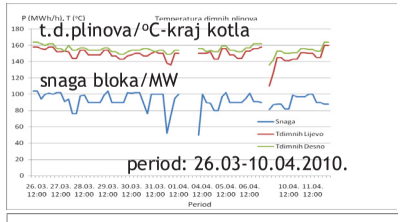
Istraživanje sklonosti prljanju kotlovskih ogrijevnih površina pri kosagorijevanju bh uglja i otpadne biomase

## Kosagorijevanje uglja i otpadne drvne biomase

Pilot projekat u TE Kakanj - blok 5, 2009-2011.

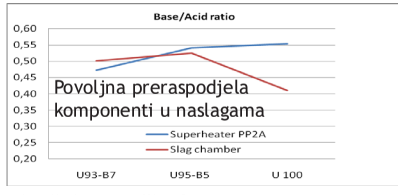


Depo: 4000 m$^3$ biomase pomiješano sa ugljem






Rastresita naslaga U93-B7*




Rezultati:

- do 10% biomase u smješi se ne javljaju poteškoće u pogonu
- nema dodatnog ulaganja; elektrostatički odvajači pepela rade bolje
- manja je vlastita potrošnja bloka, veći stepen iskorištenja

U93-B7* mješavina: 93% uglja i 7% biomase

## *8. ZAKLJUČAK*

1. Bez obzira na odluke i rješenja realno je očekivati da će bar nekoliko termoenergetskih blokova na ugalj u BiH morati biti u pogonu bar do 2040. ili 2050. godine
2. Revitalizacijom tih blokova bi se moglo postići ne samo veća proizvodnja el. energije, već i znatno smanjenje potrošnje uglja i smanejno zagađenje okoline (penali na CO2!)
3. Revitalizacija postojećih termoelektrana je moguća podrška energetskoj tranziciji u BiH
4. Planiranje obima revitalizacije i pojedinačnih zahvata mora biti podržano numeričkim simuliranjem procesa i ekspertnim mjere-njima u pogonu, sa analizom rezultata
5. Inovativne tehnologije u revitaliziranim termoelektranama i visokoefikasna ko(tri)generacija doprinise porastu energetske efikasnosti i snage postrojenja, zaštiti okoline i smanjenju rizika od daljnjeg intenziviranja klimatskih promjena

Reference


Hanjalić, K., Smajević, I., 1994, Detonation-wave technique for on-load deposit removal from surfaces exposed to fouling, Pt.I: Experimental investigation and development of the method, *ASME J. of Engineering for Gas Turbines and Power*, **116**(1): 223-230.

Hanjalić K., Smajević, I., 1994, Detonation-wave technique for on-load deposit removal from surfaces exposed to fouling, Pt.II: Full-scale application, *ASME J. of Engineering for Gas Turbines and Power*, 116 (1): 230-236

Hanjalić, K., Smajević, I., 1993, Further experience in using detonation waves for cleaning boiler heating surfaces, *Int. J. of Energy Research*, 17: 583-595

Smajević, I., Hanjalić, K., 2004, Twenty-years of successful application of on-load detonation-wave technique for cleaning gas-side boiler surfaces in a coal-fired power plant, *Power Techn. (also in German, VGB)*, 5: 1-5.

Smajević, I., Hanjalić, K., 1992, Pulsating combustion - laboratory investigation and analysis of possible application in large boilers" (in Serbocroatian), *Elektroprivreda*, 1-2: 60-65.

Smajević, I., Hanjalić, K., 1991, Some results of experimental investigation of pulsating combustion of gaseous fuels" (in Czech), *Energetika*, 8(41): 257-261.

Smajević, I., Hanjalić, K., 1995, A computational model of an aerodynamically-valved Helmoholz-type pulse combustor, In: K. Hanjalić and J.M. Kim (Eds), *Expert Systems and Computer Simulation in Energy Engineering*, 2nd Int. Forum, Erlangen, Germany. 17-20 March 1992). Begell House Inc., New York, Wallingford (UK), ISBN 1-56700-031: 316-321.

Smajević, I., Kazagić, A., Musić, M., Bečić, K., Hasanbegović, I., Sokolović, Š., Delihasanović, N., Skopljak, A., Hodžić, N., 2012, Co-firing Bosnian Coals with Woody Biomass: Experimental Studies on a Laboratory-Scale Furnace and 110 MWe Power Unit, Thermal Science, Vol. 16(3): 789-804

Kazagić, A., Smajević, I., 2009, Synergy Effects of Co-firing of Wooden Biomass with Bosnian Coal, Energy (Elsevier), 34(2008), doi: 10.1016/j.energy.2008.10.007: 699-707

Milovanovic, Z.N., Knezevic, D., Milasinovic, A., Dumonjic-Milovanovic, S.R., Ostojic, D., 2012, Modified method for reliability evaluation of condensation thermal electric power plant,*J. Safety Eng.*, 1(4): 57-67

Milovanovic, Z.N., Milasinovic, A.N., Knezevic, D.M., Skundric, J.B., Dumonjic-Milovanovic, S.R., 2016, Evaluation and monitoring of condition of turbo generatoror: the example of Tthermal Power Plant Ugljevik 1x300 MW, *American J.of Mechanical and Industrial Engineering*, 1(3): 50-57

Burdukov, A.P., Popov, V.I., Chernetskiy, M.Yu., Dekterev, A.A., Hanjalić, K., 2014, Mechanical activation of micronized coal: Prospects for new combustion applications, *Applied Thermal Engineering*, 74: 174-181

Chernetskiy, M.Yu., Dekterev, A.A., Burdukov, A.P., Hanjalić, K., 2014, Computational modelling of autothermal combustion of mechanically-activated micronized coal, *FUEL -The Science and Technology of Fuel and Energy, 135: 443-458*.

Chernetskiy M., Dekterev A., Chernetskaya N., Hanjalić K., 2018, Effects of reburning mechanically-activated micronized coal on reduction of NOx: Computational study of a real-scale tangentially-fired boiler, *FUEL, The Sci and Tech of Fuel and En* 214: 215-229.

Đugum A., Hanjalić K., 2019, Numerical simulation of coal-air mixture flow in a real double-swirl burner and implications on combustion anomalies in a utility boiler, *Energy* 170, 942-953.

BUDUĆNOST POSTOJEĆIH I NOVIH TERMOELEKTRANA U BOSNI I HERCEGOVINI U ENERGETSKOJ TRANZICIJI

PERSPECTIVES OF THERMAL POWER PLANTS IN BOSNIA AND HERZEGOVINA IN THE ENERGY TRANSITION

ANUBiH, Sarajevo, 21. novembar 2019.

# IS THE TWILIGHT OF COAL FOR THE BENEFIT OF ALL?

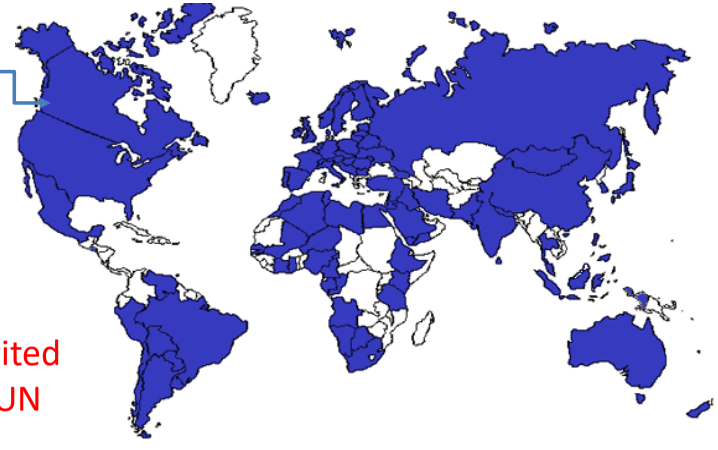
Miodrag Mesarović
ENERGOPROJEKT ENTEL
WORLD ENERGY COUNCIL SERBIA

## 2019 - 95th ANNIVERSARY OF WEC

WEC MCs

> 90% World Energy

Accredited in the UN



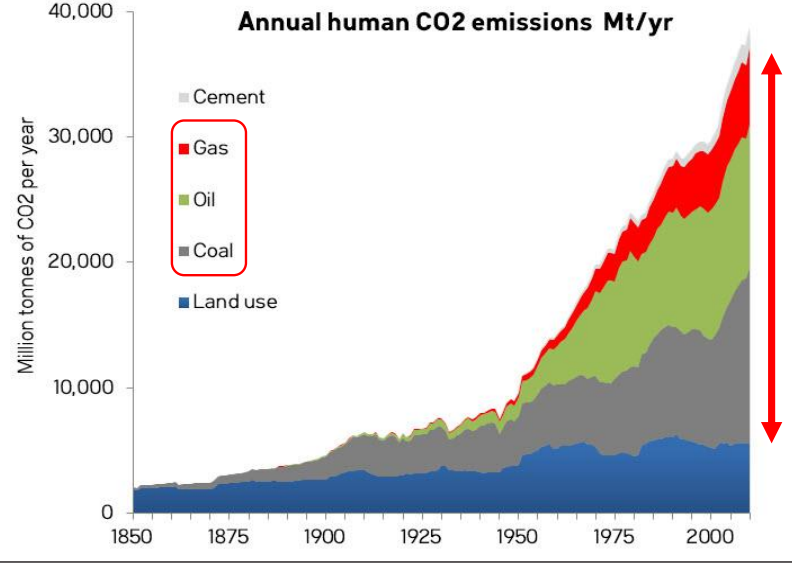
WEC Motto: SUSTAINABLE ENERGY SUPPLY FOR THE GREATEST BENEFIT OF ALL

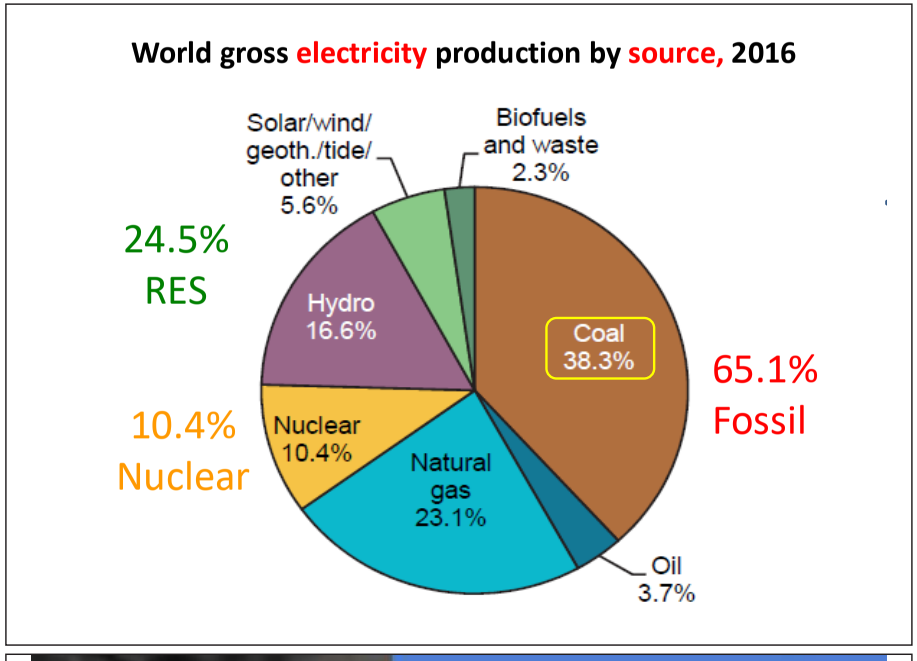
2/6/2021

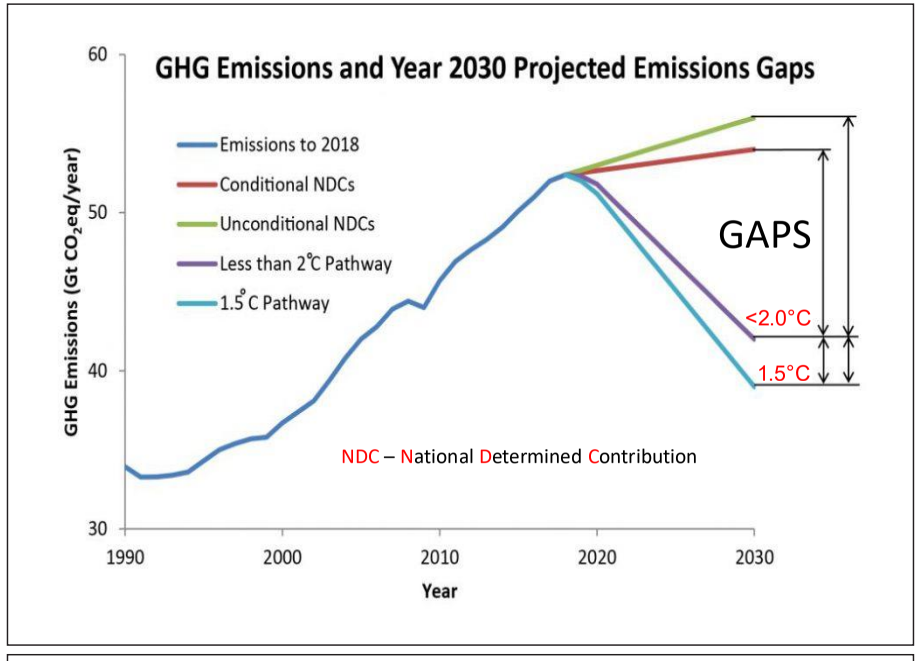
## OUTLINE OF MY PRESENTATION

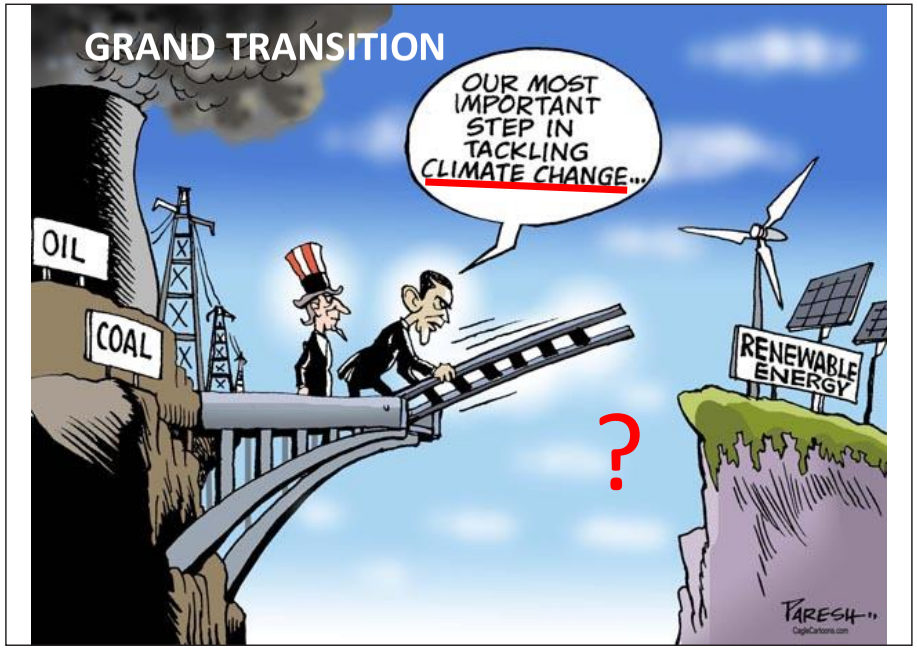
1 Energy transition as a remediation issue
2 The new role of RES in energy supply
3 Efforts to reach Paris obectives globally
4 European energy and climate policy
5 TRACER project for coal intensive regions
6 Coal in 2012 Energy Community Strategy
7 Coal perspectives in Western Balkans
8 Coal twilight in the Serbian climate strategy
9 Concluding remarks

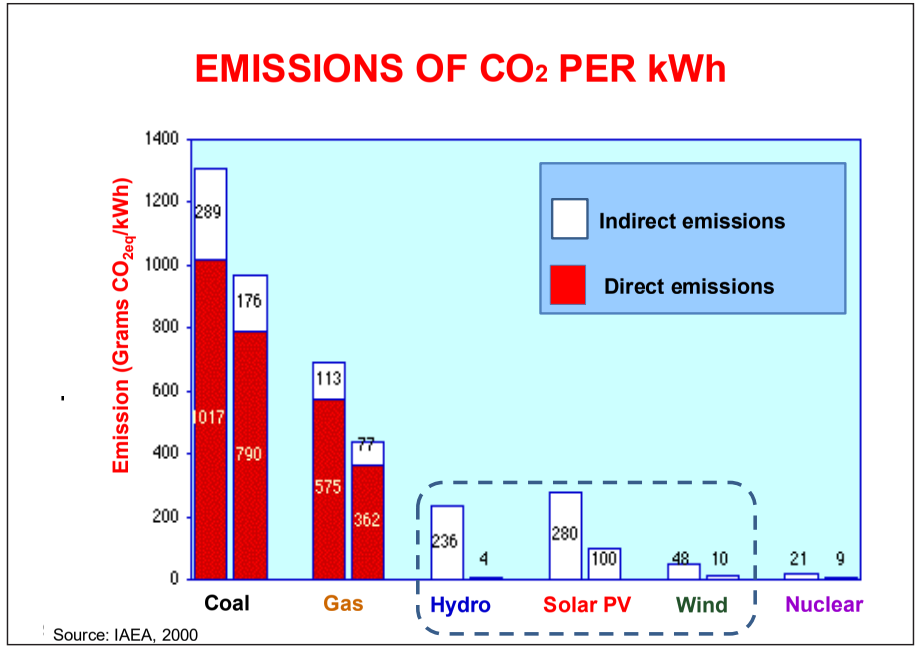
## PRINCIPAL DRIVING FORCE



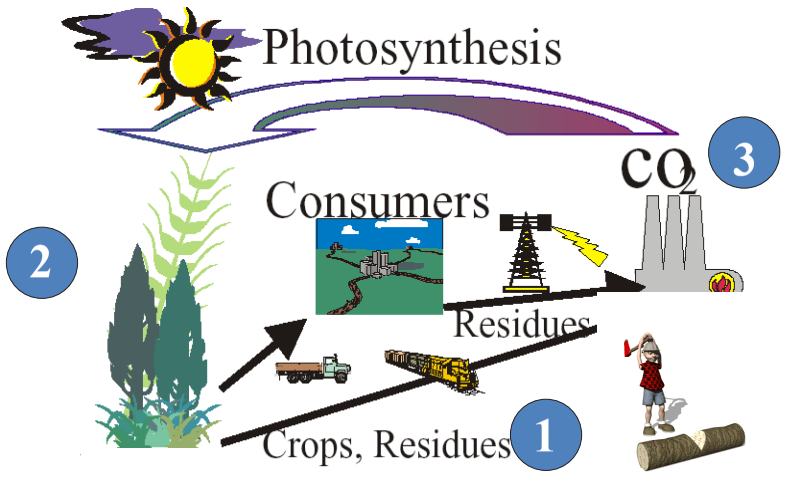

World gross electricity production by source, 2016
Solar/wind/ geoth./tide/ other 5.6%
Biofuels and waste 2.3%
24.5% RES
Hydro 16.6%
Coal 38.3%
65.1% Fossil
10.4% Nuclear
Nuclear 10.4%
Natural gas 23.1%
Oil 3.7%


GHG Emissions and Year 2030 Projected Emissions Gaps
GHG Emissions (Gt CO2eq/year)
Year
Emissions to 2018
Conditional NDCs
Unconditional NDCs
Less than 2°C Pathway
1.5°C Pathway
GAPS
<2.0°C
1.5°C
NDC – National Determined Contribution

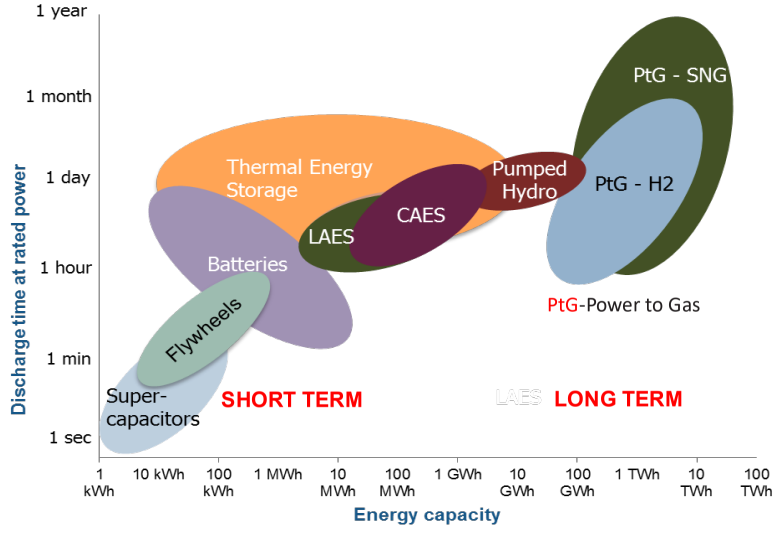

GRAND TRANSITION
OUR MOST IMPORTANT STEP IN TACKLING CLIMATE CHANGE...
OIL
COAL
RENEWABLE ENERGY
?
PARESH


EMISSIONS OF CO2 PER kWh
Emission (Grams CO2eq/kWh)
Indirect emissions
Direct emissions
Coal
Gas
Hydro
Solar PV
Wind
Nuclear
Source: IAEA, 2000

## CONTROVERSIES OVER BIOMASS



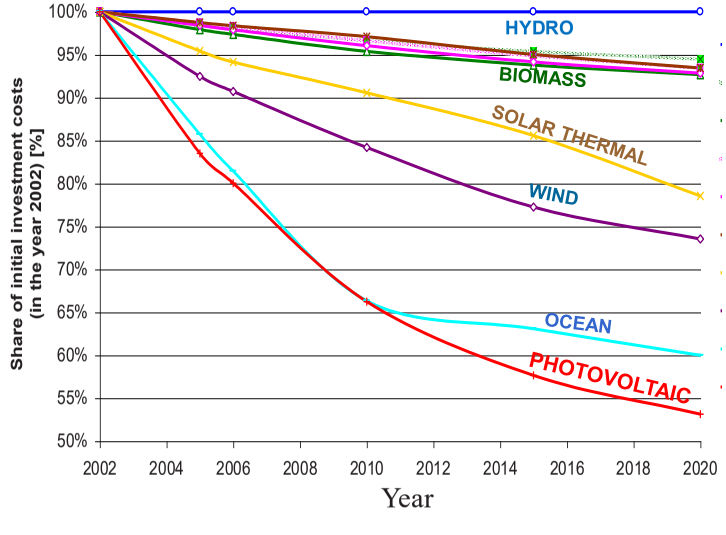

## ENERGY STORAGE



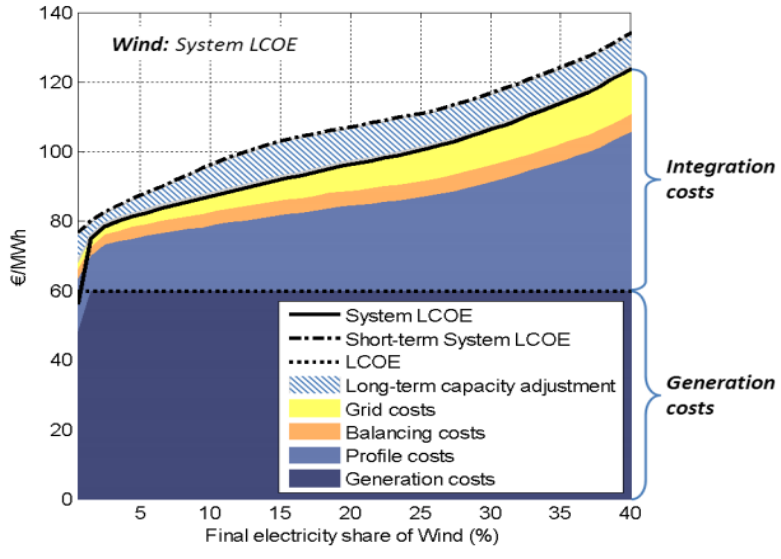

## LITHIUM-ION BATTERY STORAGE



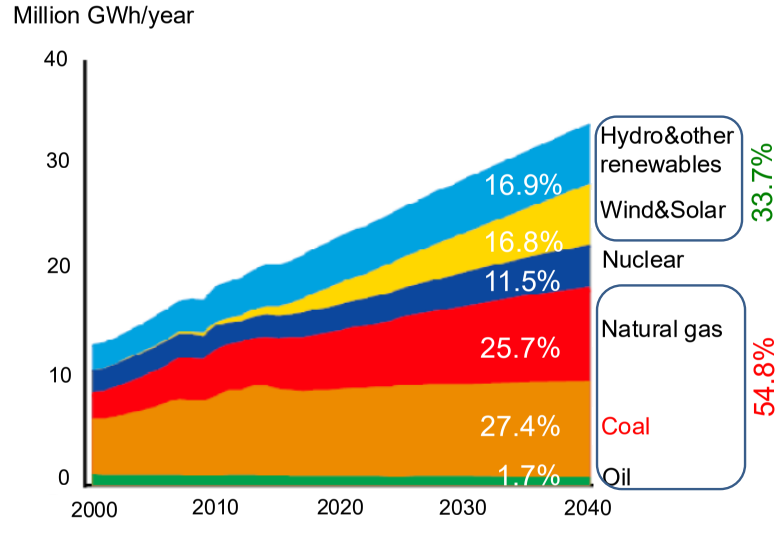

## DROP OF INVESTMENT COSTS



## LCoE vs Wind Penetration

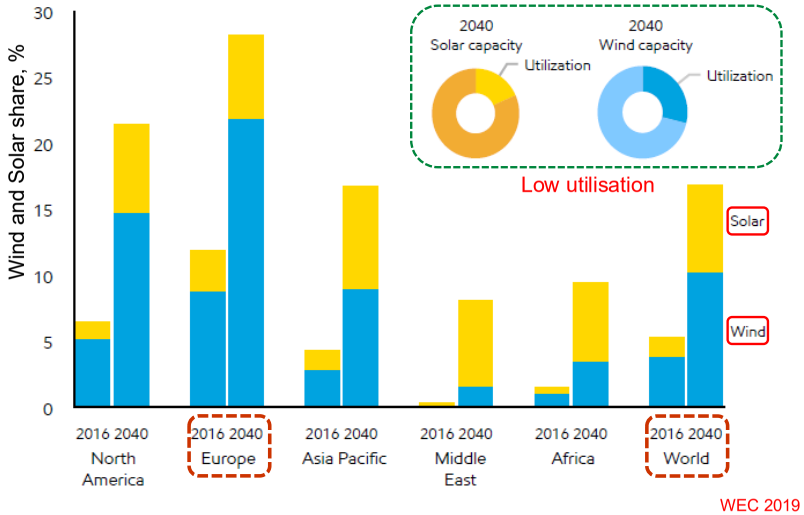



## GLOBAL ELECTRICITY GENERATION MIX



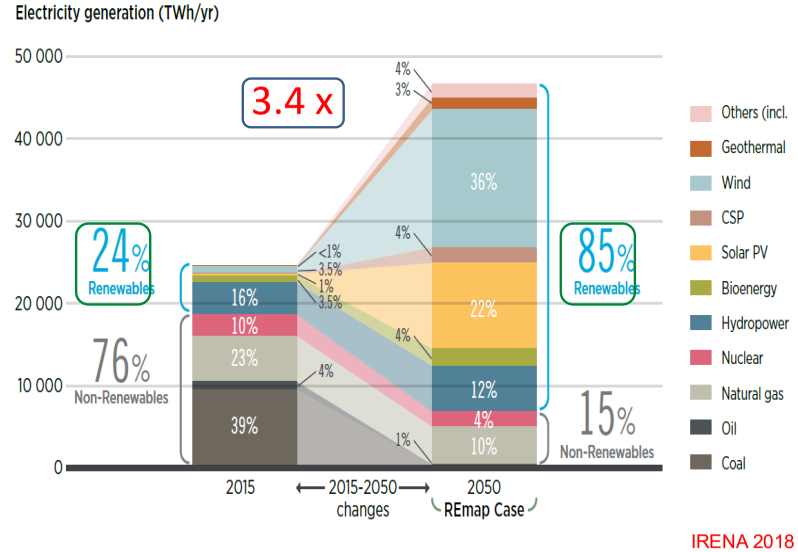

IEA 2010

## GLOBAL DISTRIBUTION OF WIND AND SOLAR



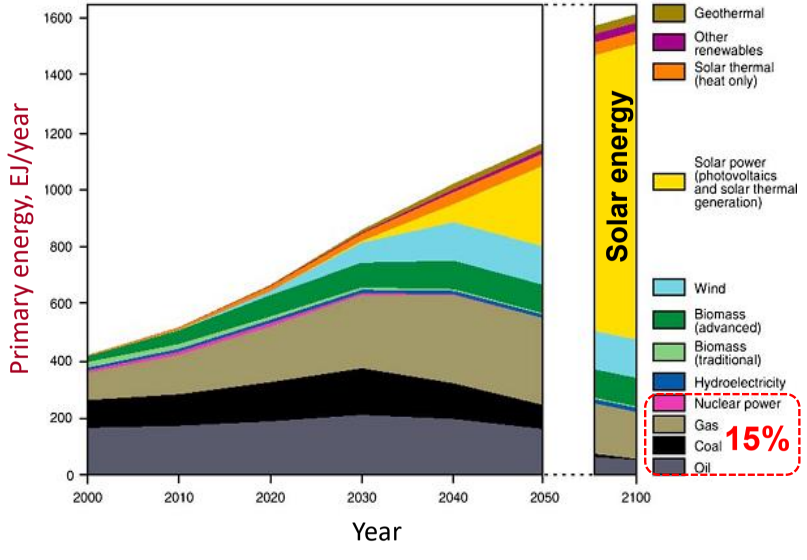

WEC 2019

## IRENA ROADMAP TO 2050

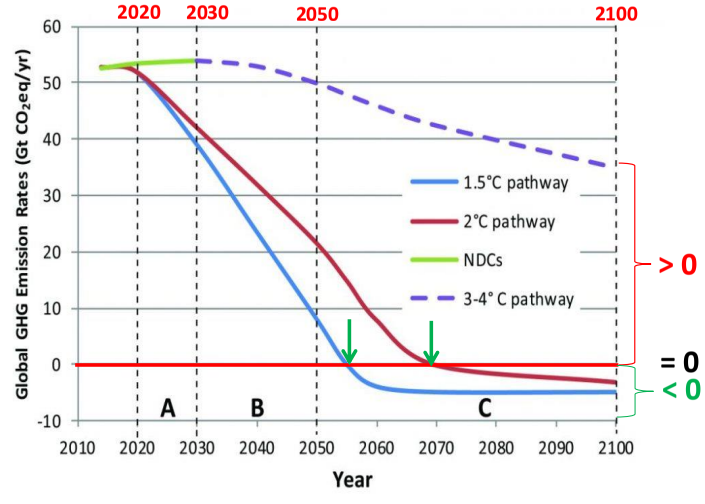



IRENA 2018

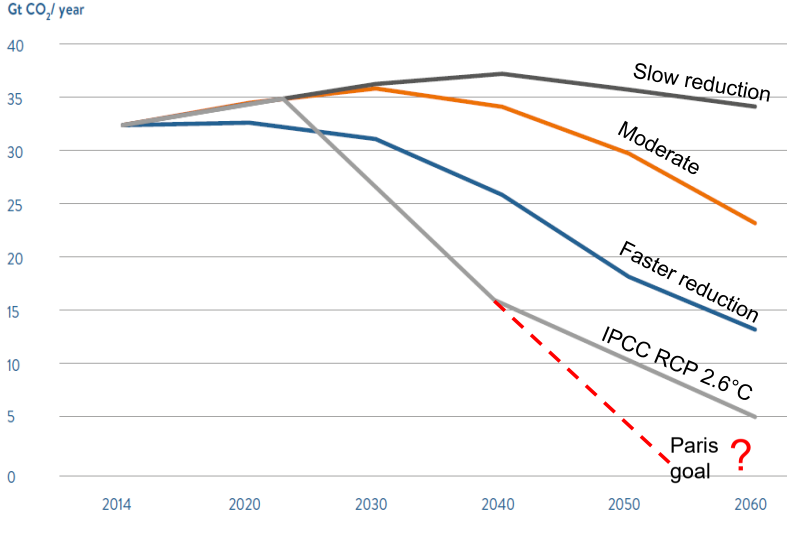
# A BRIGHT FUTURE FOR SOLAR




# PROJECTED GHG EMISSION PATHWAYS

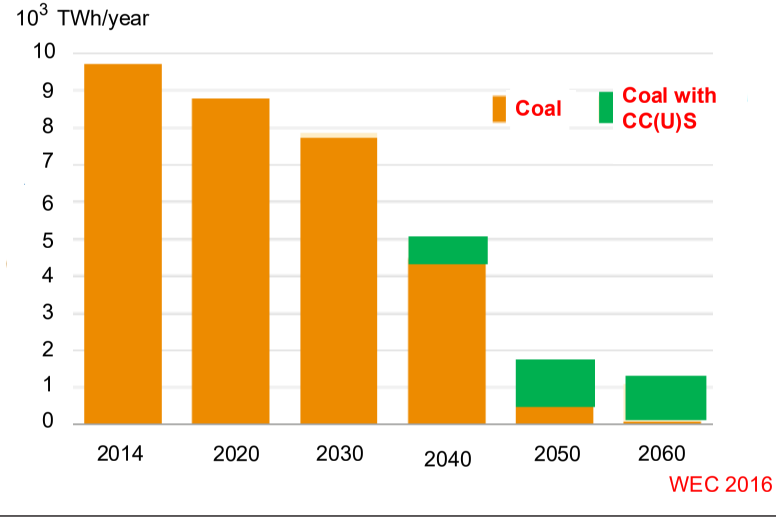



# THREE **WEC** SCENARIOS BY 2060



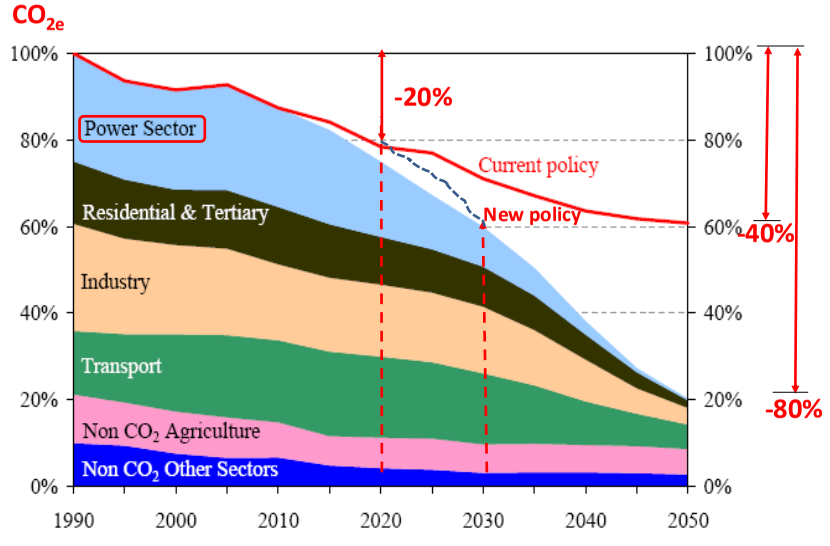

# COAL FOR POWER GENERATION

**WEC Faster Reduction Scenario**

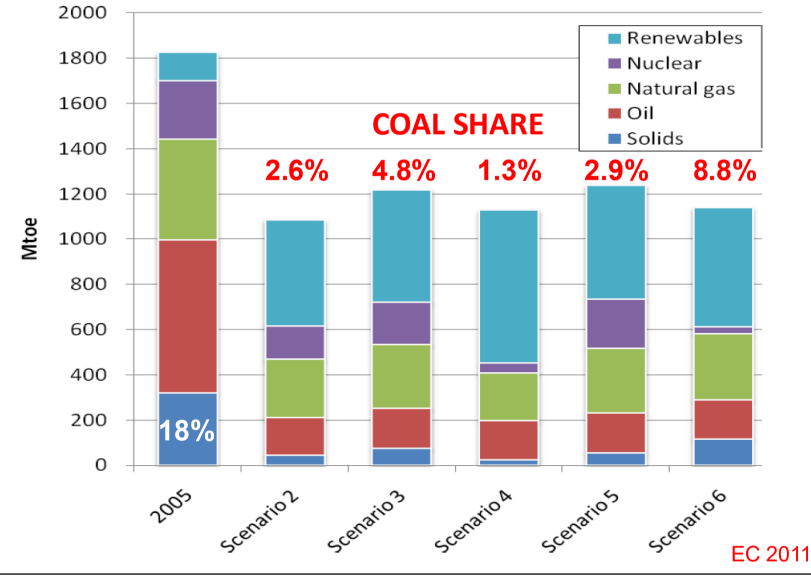



WEC 2016

## EU ENERGY AND CLIMATE PACKAGE




## EU PRIMARY ENERGY USE SCENARIOS FOR 2050




## THE EU „TRACER" PROJECT

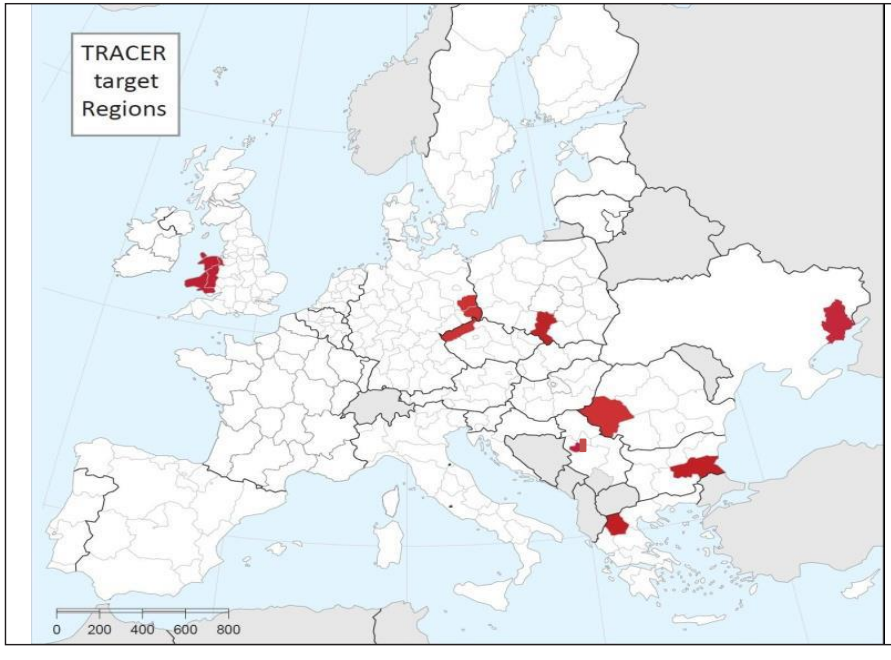
Horizon 2020

SMART SPECIALIZATION STRATEGY (S3) FOR COAL INTENSIVE REGIONS

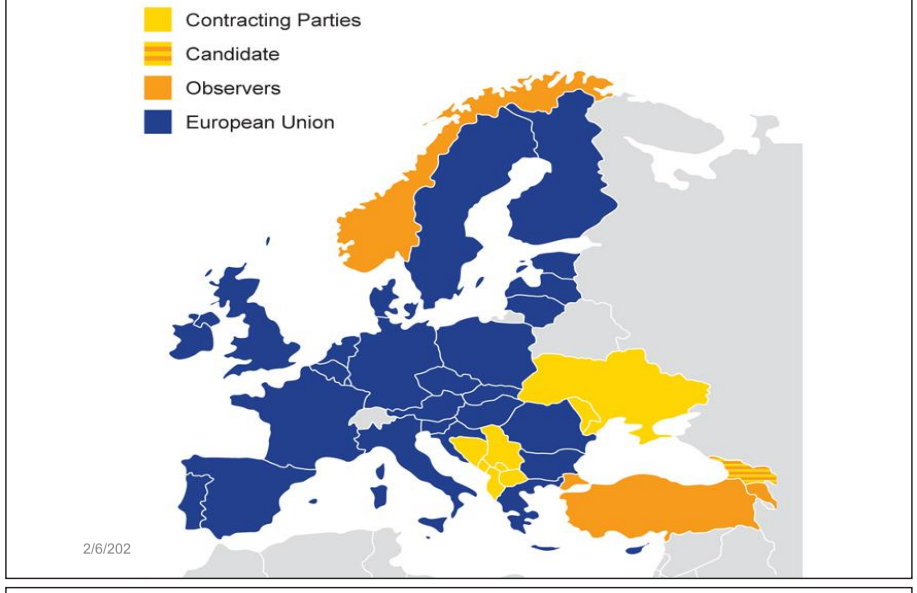
**15** CONSORTIUM MEMBERS

**11** COUNTRIES (**2** FROM EnC)

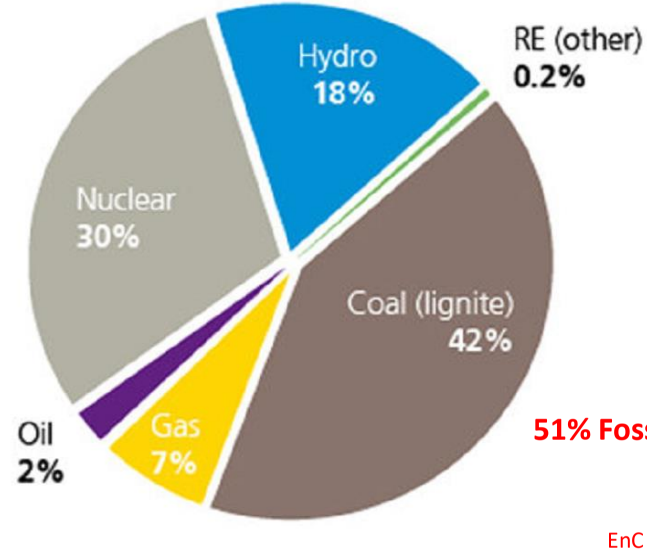
**9** COAL INTENSIVE REGIONS



## ENERGY COMMUNITY STRATEGY



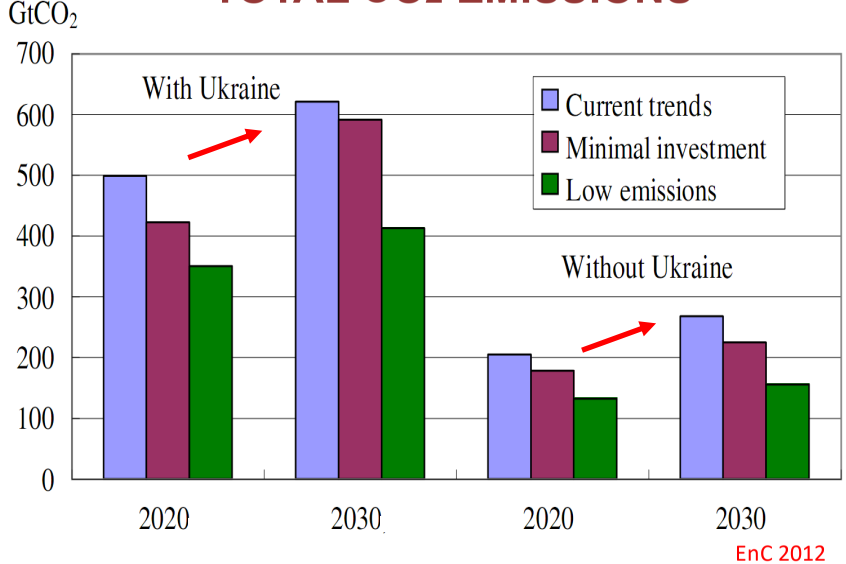

## EnC POWER GENERATION SOURCES




51% Fossil

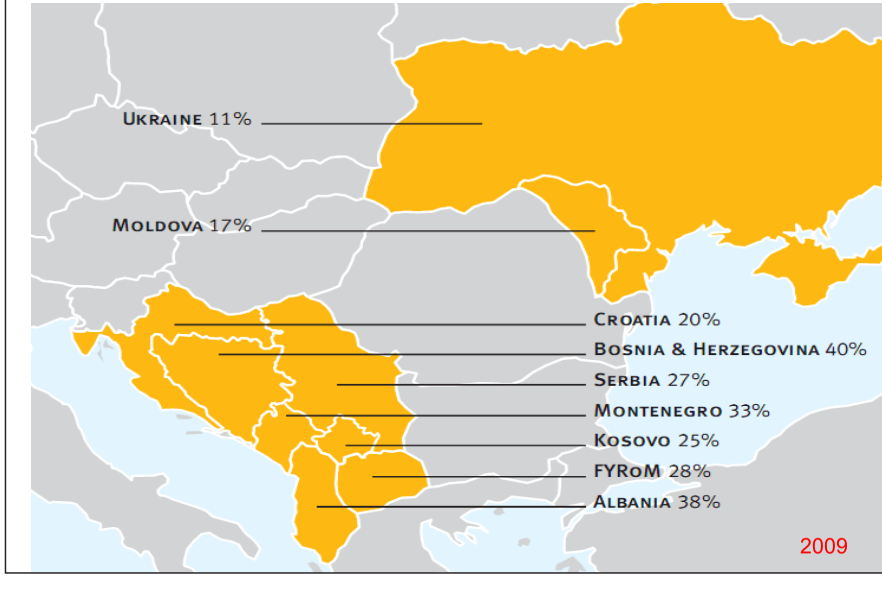
EnC 2012

## TOTAL $CO_2$ EMISSIONS



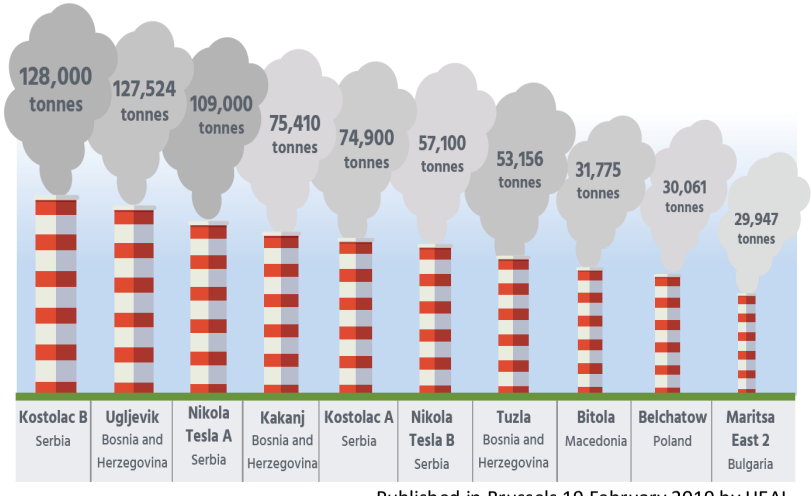

EnC 2012

## BINDING RES TARGETS IN THE EnC



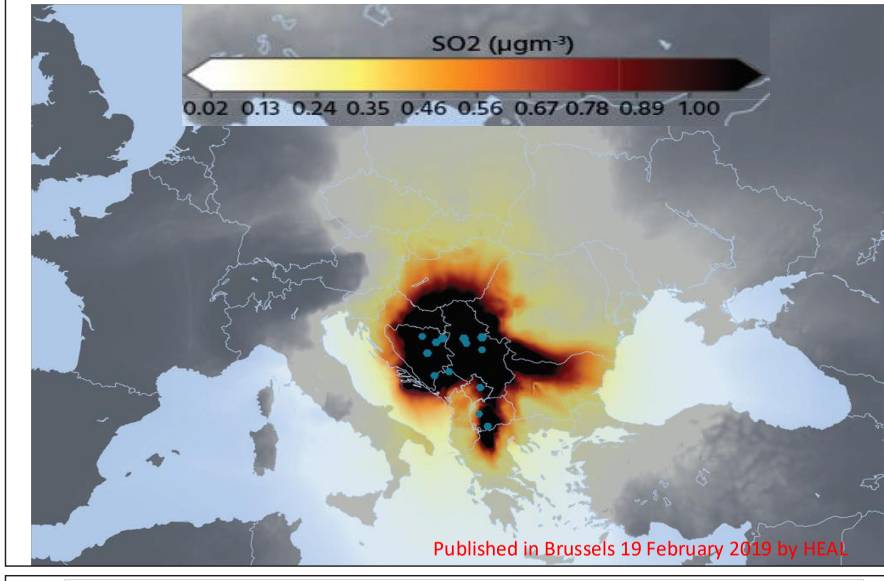
## COAL POLLUTION - EU ACTION ON THE WESTERN BALKANS

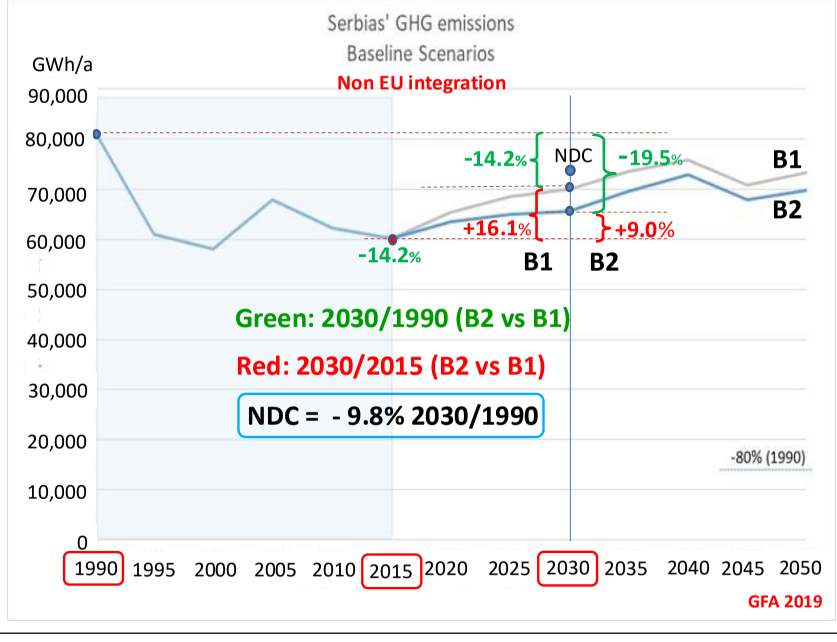
Fig. 6 Top 10 polluting plants in Europe by SO2 emissions in 2016

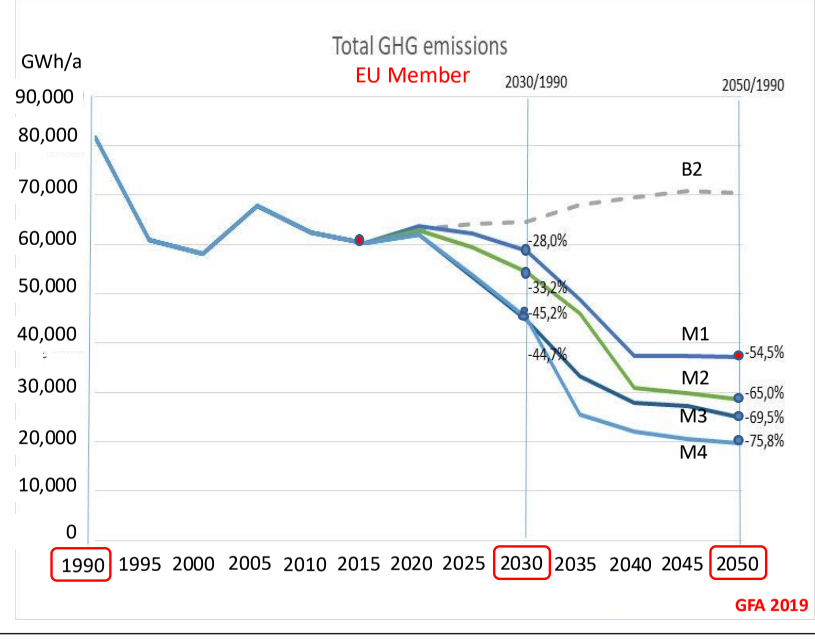



Published in Brussels 19 February 2019 by HEAL

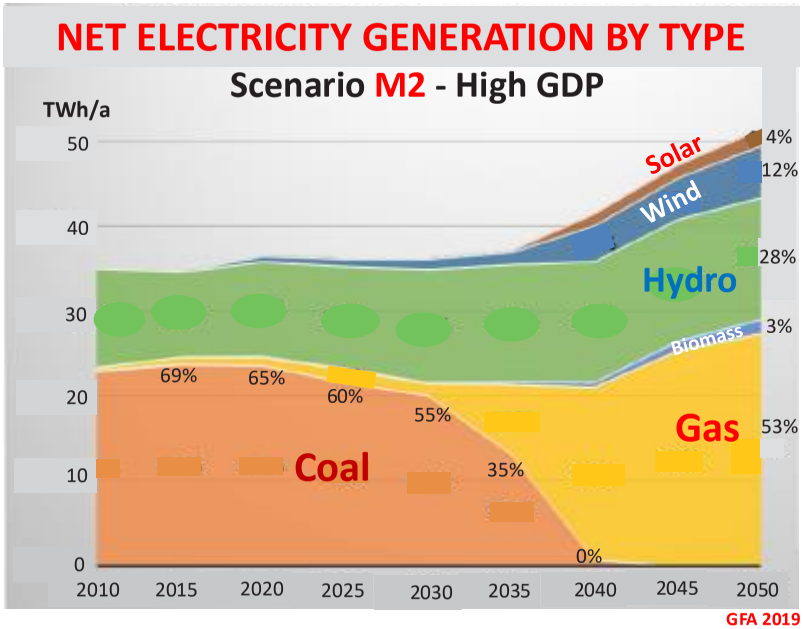
## EU FOCUS ON COAL FIRED PLANS IN WESTERN BALKANS



## NET ELECTRICITY GENERATION BY TYPE




## HISTORICAL „KOLUBARA B“ PROJECT IN SERBIA



## CONCLUSION

- Paris Agreement means temperature rise ≤ 2 °C;
- All countries should decrease their $CO_2$ emissions;
- Paris goals require coal use to decrease abruptly;
- For developing countries this goal is very difficult;
- These countries are prevented to benefit from the use of their coal resources for own development;
- Developed countries already benefited from coal and some continue so by denying human impact;
- These countries indirectly benefit even if assist poor countries financially by selling technology.
- Common transitional goals - but different paths.

ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA (ANUBiH)

PUBLIC ENTERPRISE ELEKTROPRIVREDA OF BOSNIA AND HERZEGOVINA (EPBiH)

# *Budućnost novih termoelektrana u BiH oslonjenih na kogeneraciju, integraciju biogoriva i optimizaciju procesa*


*dr. Anes Kazagić, EPBiH*
*Prof. Dr. Petar Gvero, Uni Banja Luka*
*mr. Miladin Trbić, TE Stanari*
*Prof. dr. Izet Smajević, ANUBiH*



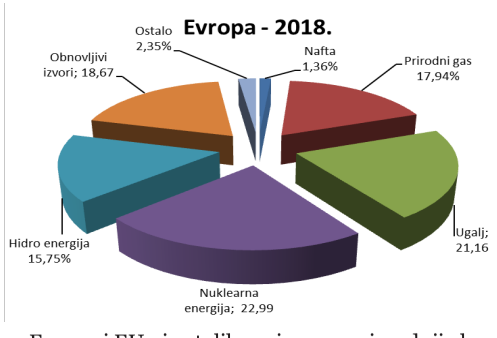
NAUČNO-STRUČNO SAVJETOVANJE
**BUDUĆNOST POSTOJEĆIH I NOVIH TE U BOSNI I HERCEGOVINI U ENERGETSKOJ TRANZICIJI**
21. novembar 2019. godine, Akademija nauka i umjetnosti Bosne i Hercegovine, Bistrik 7, 71000 Sarajevo



*Budućnost novih termoelektrana u BiH oslonjenih na kogeneraciju, integraciju biogoriva i optimizaciju procesa*


**– iz globalne perspektive**

## Učešće energenata u proizvodnji el. energije u Evropi (2018) vs klimatske promjene



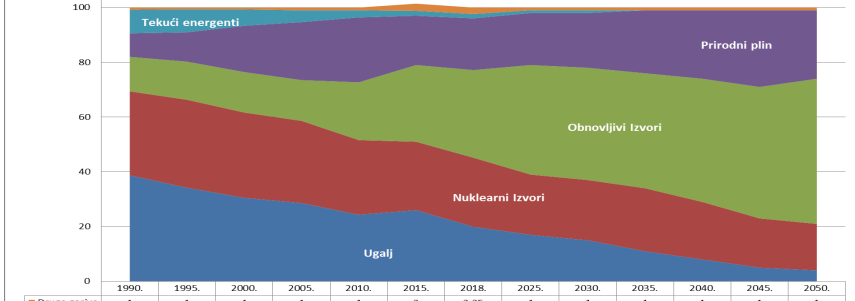

| Energent | Terawat-sat | % |
|---|---|---|
| Nafta | 56 | 1,37 |
| Prirodni gas | 731,3 | 17,94 |
| Ugalj | 862,7 | 21,16 |
| Nuklearna en. | 937,5 | 22,99 |
| Hidro energija | 642,1 | 15,75 |
| Obnovljivi izvori | 761,1 | 18,67 |
| Ostalo | 86,6 | 2,12 |
| | 4.077,3 | 100,00 |

Evropa i EU nisu toliko ovisne o proizvodnji el. energije iz fosilnih goriva.

Učešće fosilnih goriva u proizvodnji električne energije u Evropi i EU je na nivou 40,5% što je još uvijek dosta visok procenat koji se vrlo sporo smanjuje.

Podaci IEA

## PROJEKCIJE PROIZVODNJE EL. EN. U EU DO 2050.

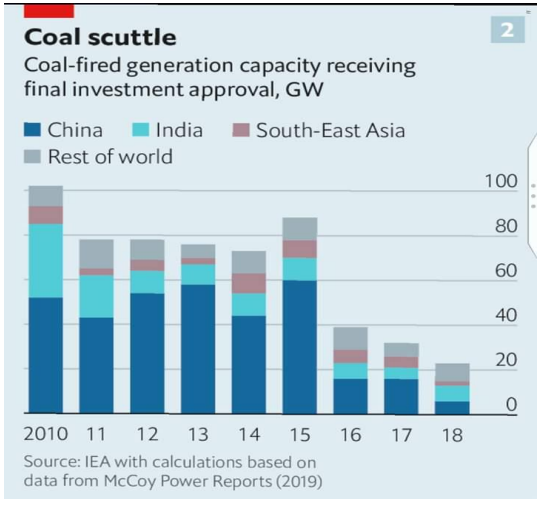



| | 1990. | 1995. | 2000. | 2005. | 2010. | 2015. | 2018. | 2025. | 2030. | 2035. | 2040. | 2045. | 2050. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Druga goriva | 1 | 1 | 1 | 1 | 1 | 3 | 2,35 | 1 | 1 | 1 | 1 | 1 | 1 |
| Nafta | 9 | 8 | 6 | 4 | 3 | 2 | 1,6 | 1 | 1 | 0 | 0 | 0 | 0 |
| Prirodni gas | 9 | 11 | 17 | 21 | 24 | 18 | 18,88 | 19 | 20 | 23 | 25 | 28 | 25 |
| Obnovljivi | 13 | 14 | 15 | 15 | 21 | 28 | 32 | 40 | 41 | 42 | 45 | 48 | 53 |
| Nuklearni | 31 | 32 | 31 | 30 | 27 | 25 | 25,21 | 22 | 22 | 23 | 21 | 18 | 17 |
| Ugalj | 39 | 34 | 31 | 29 | 24 | 26 | 19,96 | 17 | 15 | 11 | 8 | 5 | 4 |

**Dekarbonizacija EU – ciljevi do 2050.**

- Prirodni gas: povećanje na 25%
- Obnovljivi izvori: Solar, hidro i vjetar - povećanje na 53%
- Nuklearna energija: smanjenje na 17%
- Nafta: potpuno izbacivanje
- Ugalj: smanjenje na 4-6%

## Investicije u TE na ugalj u svijetu 2010-2018.




## Coal phase-out - neke činjenice

**Neke najrazvijenije zemlje Evrope razmatraju ili planiraju potpuno izbacivanje uglja (Coal Phase-out) iz proizvodnje el. energije do 2050. (npr. Njemačka do 2038), a samo je nekolicina do sada donijela takve odluke (npr. Danska, Finska, Holandija, Irska), ali se to ne odnosi na TE koje koriste coal/biomass/gas co-firing.**

**Postoje kontroverzne izjave i u samoj EU: Grčka je npr. najavila mogućnost izbacivanja uglja do 2028, a ujedno gradi termoblok na domaći lignit Ptolemaida 660 MW, puštanje u pogon je do 2023.**

## KLJUČNA PITANJA U PROCESU ENERGETSKE TRANZICIJE

- **Klimatske promjene se neupitno dešavaju i predstavljaju prijetnju za civilizaciju - utimativno je da se poduzmu mjere kako bi se ublažile. Potrebno je značajno smanjenje emisije CO2 !!**
- **Učešće fosilnih goriva je 64% a uglja 38% u proizvodnji el. en. na svjetskom nivou. Ovi procenti se sporo mijenjaju.**
- **Naglo izbacivanje fosilnih goriva, a prije svega uglja iz upotrebe dovelo bi do manjka i poskupljenja el. energije, što bi ugrozilo i najmoćnije ekonomije svijeta. Fosilna goriva, tako i ugalj, je stoga jedino moguće postepeno izbaciti iz upotrebe.**
- **Obnovljivi izvori učestvuju sa 9% - procjene govore da će 2050. kada na zemlji bude 9,7 milijardi stanovnika (Studija Ujedinjene nacije) OI moći podmiriti oko 20% potreba za el. energijom. Broj stanovnika se konstantno povećava kao i potražnja za energijom, i veliki je izazov kako će se dugoročno obezbijediti potrebna energija.**
- **Obnovljivi izvori nisu potpuno upravljivi. Tek se treba desiti ključni tehnološki napredak u pogledu skladištenja energije.**

*Budućnost novih termoelektrana u BiH oslonjenih na kogeneraciju, integraciju biogoriva i optimizaciju procesa*

**– iz nacionalne BiH perspektive**

## Postojeće termoelektrane na ugalj u BiH

1. TE Kakanj, 450 MWe (+300/30 MWt), 1956. god.
2. TE Tuzla, 723 Mwe (+220/150 MWt), 1963. god.
3. TE Gacko, 300 MWe, 1982. god.
4. TE Ugljevik, 300 MWe, 1985. god.
5. TE Stanari, 300 MWe, 2016. god.

**Total: 2073 MWe (+520/180 MWt)**

## Zamjenski blokovi vs nove TE na ugalj u BiH

1. TE Tuzla, Blok 7*, - zamjenski blok (mijenja blokove 1-5).
2. TE Kakanj, blok 8, - zamjenski blok (mijenja blokove 1-6).
3. TE Gacko, - zamjenski blok postojećeg bloka.
4. TE Ugljevik, - zamjenski blok postojećeg bloka.
5. TE Banovići, - nova TE.
6. TE Kongora, - nova TE.
7. TE Kamengrad, - nova TE.

**Zamjesnki blokovi smanjuju emisiju CO2, nove TE povećavaju emisiju CO2!**

## Značaj proizvodnje električne energije na ugalj u BiH - neke činjenice

- Ugalj je energent koji na nivou BiH učestvuje sa 60% a na nivou FBiH sa 80% udjela u ukupnoj proizvodnji električne energije.
- Sektor uglja obezbjeđuje masovno zapošljavanje: cca 16.000 radnika + prateće industrije
- FBiH 11.200 radnika u rudnicima (Rudnici Koncerna EP BiH 8.300, RMU Banovići 2.900) EP BiH 4.430 radnika, UKUPNO: 15.630 radnika
- BiH ukupno uposlenih u elektroprivrednim kompanijama 27.224 radnika, F BiH 17.759 i EP RS 9.465 radnika
- HEP ima 11.000 radnika, u Srbiji broj radnika u rudnicima je 24.000.
- EU 240.000 ljudi: 180.000 u rudarstvu i oko 60.000 u termoelektranama na ugalj.
- Sektor OIE u BiH ne može zaposliti tako značajan broj ljudi.
- Klimatske promjene su prijetnja - Fosilna goriva treba zamijeniti sa OI i u BiH, ali postupno, sa realnim planom, dinamikom i jasnom alternativom.

## ENERGETSKA TRANZICIJA U BIH - OTVORENA PITANJA

- **BiH je ovisna o proizvodnji el. energije iz uglja 60% i ne može bez uglja u bližoj perspektivi zadovoljiti svoje potrebe za električnom energijom.**

**Ako bi se desila brza transformacija i izbacivanje uglja iz upotrebe, desio bi se veliki poremećaj tržišta el. energije u BiH, u smislu snabdijevanja i cijena el. energije.**

- **Naglim izbacivanjem uglja iz upotrebe slijedi potpuno gašenje rudarskog sektora, veliko otpuštanje radnika, BiH gubi energetsku neovisnost, gubitak prihoda što će uzdrmati BDP BiH, a posljedice bi bile velike za penzioni i zdravstveni fond te prateće industrije i sve što prati rudarski i energetski sektor.**

**Uklanjanju uglja mora se ponuditi jasna i održiva alternativa, a energetsku tranziciju mora pratiti odgovorna socijalna tranzicija (tranzicija zanimanja, promjena školskih programa i dr.).**

## Rezerve i kvalitet uglja u BiH
## - domaći energetski resursi vs uvozna energija

- Rezerve uglja u BiH su cca 5.6 milijardi tona.
- Mrki ugljevi u BiH su relativno dobrog kvaliteta sa prosječnom toplotnom vrijednošću oko 16,750 kJ/kg, ali sadrže znatne količine ukupnog sumpora (2-6%), pepela (10-45%) i vlage (10-25%).
- Ligniti u BiH su kvalitetni, čisti, toplotne vrijednosti; 7.500-12.600 [kJ/kg], 0,2-1,0% ukupnog sumpora, pepela 5-20% i vlage 30-50%.

## Resurs biomase u BiH
## - domaći energetski resursi vs uvozna energija

*Table 34: Quantities, types, structure and energy-related potential of wood residue in Bosnia and Herzegovina (based on an average volume of cutting in the period of 2007 – 2010.)*

| Item | | | Quantities [m³/a] | Quanti-ties [t/a] | Minimum calorific value [GJ/t] | Energy potential [TJ/a] |
|---|---|---|---|---|---|---|
| Wood residues from forestry | | broadleaf | 295.529 | 212.781 | 10,28 | 2.187 |
| | | conifers | 202.866 | 91.290 | 10,28 | 938 |
| Sawmill wood residues | Sawdust | broadleaf | 283.300 | 203.976 | 10,29 | 2.097 |
| | | conifers | 145.227 | 65.352 | 10,28 | 672 |
| | Wood chips | broadleaf | 212.475 | 152.962 | 10,28 | 1.573 |
| | | conifers | 145.227 | 65.352 | 10,28 | 672 |
| Total | | | 1.284.624 | 791.733 | - | 8.139 |



Type of biomass to be used in TPP BiH:

- Forest residues
- Waste wooden biomass - swadust and chips
- Agricultural biomass residues
- Energy crops

## Ključna pitanja za dugoročni rad TE u BiH

- Proizvodni troškovi (pogonski troškovi, cijena uglja, naknade, okolinski zahtjevi, takse za $CO_2$)
- Struktura proizvodnog portfolia i uloga postojećih TE.
- Redukcija emisija prema NERP, IED, NECP ($CO_2$)
- Dinamika realizacije investicija u postojeće TE
- Planovi realizacije zamjenskih kapaciteta u postojećim TE
- Potrebe za ugljem, status i poslovanje rudnika
- Finansijski položaj EP / investicioni kapacitet
- Cijene električne energije: Otvaranja tržišta i pojava konkurencije, (ne)ekonomske cijene domaćinstava
- En. zajednica i EU ciljevi (OIE, emisije, efikasnost, Takse $CO_2$, Coal phase-out...)
- Mogućnost visokoefikasnse kogeneracije
- Mogućnost korištenja biomase kao sekundarnog goriva

## Ključni uticajni faktori - obaveze iz ugovora o EnZ i pristupa EU - IED/NERP i NECP

1. Realizacija NERP-a (2018-2027)
2. EU ciljevi 2021-2030 u odnosu na ref. god. (1990?, 2012?):

- **Smanjenje emisija stakleničkih plinova za 40%**
- **Povećanje udjela obnovljivih izvora do učešća od 32% u ukupnoj finalnoj potrošnji energije**
- **Povećanje energetske efikasnosti za 32,5%**

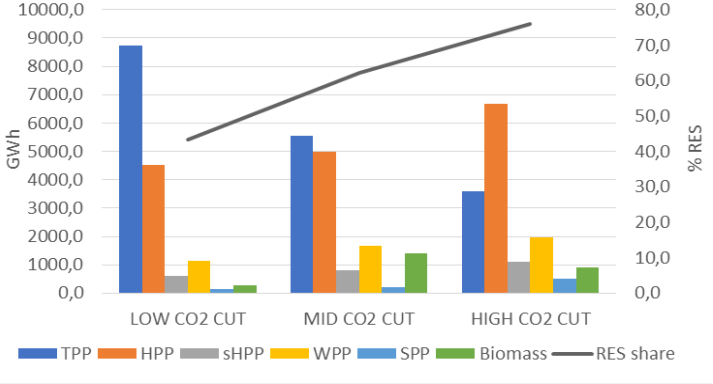
Za emisije koje su u ETS-u -43% $CO_2$ u odnosu na 2005, za BiH prema NECP mogući zahtjev je -12% $CO_2$ u odnosu na 2014 ili 2016. do 2030.

*Budućnost novih termoelektrana u BiH oslonjenih na kogeneraciju, integraciju biogoriva i optimizaciju procesa*

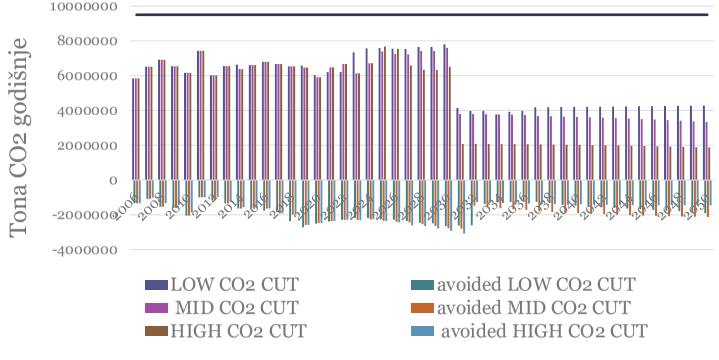
## Dugoročni ciljevi Elektroprivrede

- energetska neovisnost - korištenje domaćih resursa za proizvodnju električne i toplinske energije.
- ekonomski rast - konkurentne cijene energije i više radnih mjesta.
- okolinski prihvatljivo poslovanje.
- zadovoljstvo i zaštita krajnjih potrošača.
- **da se kroz tranziciju u realnom vremenskom okviru primat prepušta obnovljivim izvorima energije.**
- Zamjenski termoblokovi EP su potrebni da bi se obezbijedila priuštiva električna energija za svakog stanovnika BiH, priuštiva toplinska energija za okolne gradove (Primjer TE Tuzla u Tuzlanskom kantonu), te omogućila **održiva tranzicija ka EES baziranom na OIE**.

## Primjer projekcije portfolia EPBiH - 2050

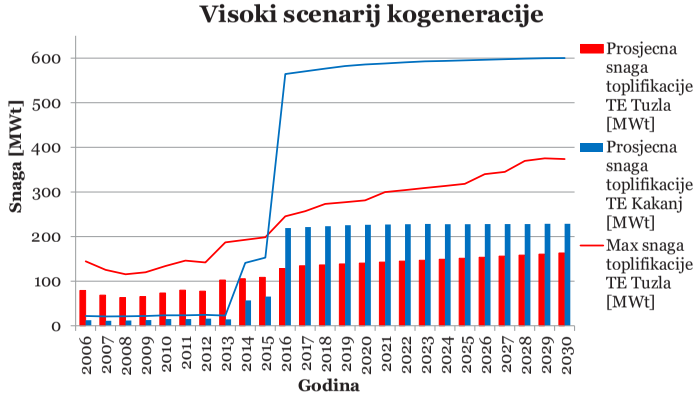



## Scenariji smanjenja CO2 u EPBiH do 2050

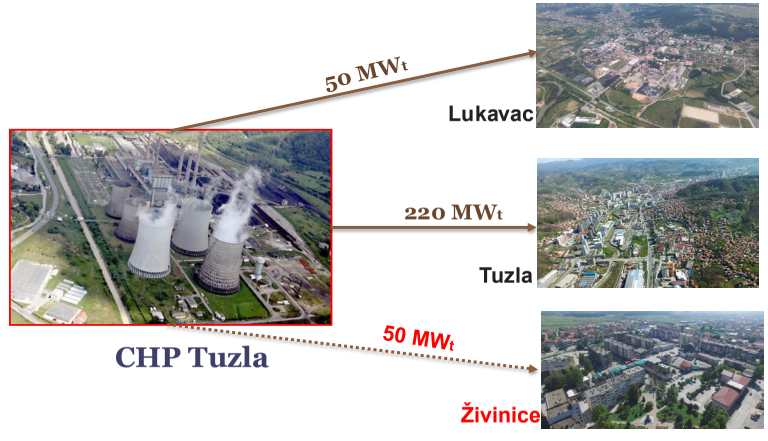


## Proširenje kogeneracije - primjer Tuzla i Kakanj - novi sistemi daljinskog grijanja

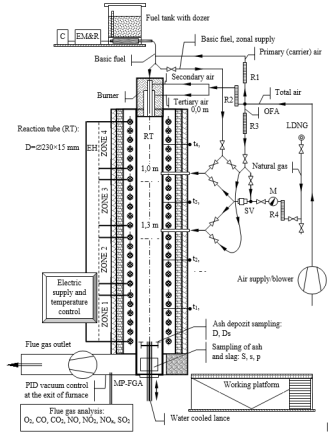
- DHS Zivinice - from Tuzla CHP (+50 MWt)
- DHS area to/incl. Sarajevo (+300 MWt) – from Kakanj TPP




## Tuzla DHS – moguća visokoefikasna kogeneracija




## Projekti kosagorijevanja s biomasom u TE BiH - R&D - Lab-scale tests na MFS




1 TET5:WB = 93:7%w
2 TET5:WB = 85:15%w
3 TET5:M = 93:7%w
4 TET7:WB = 85:15%w
5 TET7:WB:M = 80:13:7%w
6 TET7:WB:M = 75:15:10%w
7 TEK6:WB = 85:15%w
8 TEK6:WB = 75:25%w
9 TEK6:M = 93:7%w
10 TEK8:WB = 75:25%w
11 TEK8:WB:M = 85:8:7%w
12 TEK8:WB:M = 75:15:10%w



## 0.1-rate biomass co-firing trial run at Kakanj CHP



Characteristics of wooden biomass supplied:
- Particle size: max 8 mm (wooden sawdust)
- Hd = 12-14 MJ/kg, W = 20%, A = 0.3%

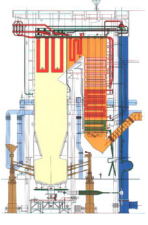




## BIOFIT - pokrenuti su projekti s biomasom EPBiH

- ✓ Kosagorijevanje (do 30%w) na bloku 6, 223 MWe u TE Tuzla
- ✓ Potpuna konverzija na biomasu na bloku 5, 118 MWe u TE Kakanj



- ✓ Blok 7 TE Tuzla moći će u perspektivi koristiti biomasu kao sekundarno gorivo

## Okolinski indikatori EPBiH sa zamjenskim blokovima

| **Okolinski aspekt** | | 2017 | 2020 | 2025 | **2030** | 2030/17 |
|---|---|---|---|---|---|---|
| $SO_2$ | t/a | 151.517 | 125.550 | 29.449 | **4.065** | -97% |
| NOx | t/a | 15.075 | 13.188 | 6.645 | **4.354** | -71% |
| PM | t/a | 1.011 | 792 | 272 | **225** | |
| $CO_2$ | hilj. t/a | 6.469 | 5.517 | 5.551 | **5.769** | -11% |
| Neto efikasnost TE | % | 30,9 | 30,6 | 34,7 | **38,5** | 25% |

| **Okolinski aspekt** | | 2017 | 2020 | 2025 | **2030** | 2030/17 |
|---|---|---|---|---|---|---|
| $SO_2$ | t/MWh | 25,2 | 24,3 | 12,2 | **0,7** | -97% |
| NOx | t/MWh | 2,5 | 2,5 | 1,9 | **0,6** | -76% |
| PM | t/MWh | 0,17 | 0,15 | 0,05 | **0,04** | |
| $CO_2$ | t/MWh te | 1,08 | 1,07 | 1,00 | **0,92** | |
| $CO_2$ | t/MWh uk | 0,92 | 0,83 | 0,74 | **0,68** | |

## TE Stanari, pušten u pogon 2016.

Blok TE Stanari je instalisane snage 300 MW sa potkritičnim parametrima pare i CFS kotlom (sagorijevanje u cirkulacionom fluidizovanom sloju).

Osnovni tehnički podaci o bloku 300 MWe Stanari su:

- garantovana vremenska raspoloživost 90%
- godišnja prizvodnja el. energije na bazi 7500 radnih sati 2.000 GWh
- časovna potrošnja projektnog uglja 304 t
- Specifična vrijednost $CO_2$ za gorivo 1,01 kg/kg
- godišnja potrošnja projektnog uglja 2.315.000 t
- sopstvena potrošnja bloka 27 MW
- snaga na pragu TE 273 MW
- specifična potrošnja toplote 9.365 KJ/kg
- stepen korisnosti bloka-bruto 40%
- stepen korisnosti-neto 36%

## Izgradnja TE Stanari

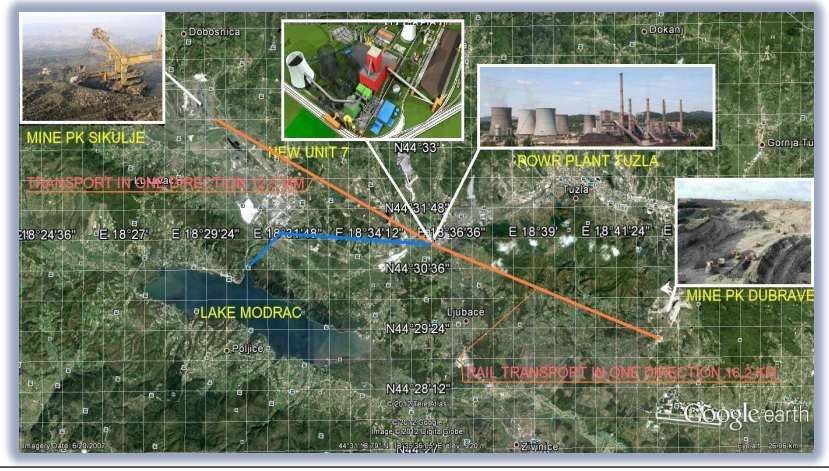


# Iskustva TE Stanari, 2016

- Kotao je opremljen uređajima za redukciju emisije $SO_2$. Emisija $SO_2$ redukuje se dodavanjem krečnjaka kao sorbenta direktno u ložište kotla.
- Buggy dust filters.
- TE ima suvi rashladni sistem (vazduhom hlađeni kondenzator), potpunu preradu otpadnih voda bez ispuštanja u okolne vodotokove a odlaganje pepela se vrši u posebno pripremljene vodonepropusne kasete.
- Ostvarena proizvodnja (neto prag) u prethodnom periodu je 2017 . – 2.040.592 , a 2018 – 2.056.001 (MWh)
- Srednje mjesečne vrednosti emisija za period januar 2017– decembar 2018. su: $SO_2$ - 196 mg/mn$^3$, $NO_x$ 169 mg/mn$^3$ i čvrste čestice 6,65 mg/mn$^3$
- Emisije u vazduh u potpunosti ispunjavaju ELV definisane lokalnim propisima i LCP direktivom, a uzmemo li u obzir zahtjeve IED direktive (koji stupaju na snagu najkasnije 1. 1. 2028. godine) vidljivo je da TE Stanari može da ih poštuje.

## BLOK 7 Tuzla kao energetski kompleks integriran s OIE

TE Tuzla i rudnici Kreka, HE Modrac, SDG Tuzla iz kogeneracije sa integrisanim modulima biomass co-firing, solar thermal kolektorima i toplinskim pumpama




# Blok 7 - State-of-the-art CCT

- **Izgradnjom bloka 7 (450 MWe, 270 MWt) obezbjeđuje se djelomična zamjena kapaciteta postojećih blokova koji izlaze iz pogona (2x32 MW + 1x100 MW + 2x200 MW = 564 MWe, 220 MWt).**
- **Izgradnjom bloka 7 se obezbjeđuje racionalni kontinuitet proizvodnje uglja i prestrukturiranje Rudnika «Kreka» u sklopu Koncerna JP EPBiH.**
- **Blok 7 se gradi kao kogeneracijski blok, čime se obezbjeđuje dugoročno snabdijevanje toplotnom energijom okolnih gradova (270 MWt), umjesto bloka 3 i bloka 4 sa kojih se sada obezbjeđuje daljinsko grijanje (220 MWt).**
- **Povećanje energetske efikasnosti i u skladu s tim smanjenje emisije stakleničkih plinova (blokovi koji izlaze iz pogona imaju stupanj korisnosti cca 30%, a novi blok 7 u kondenzacionom režimu 42,64%, a u kogenerativnom radu preko 50%).**
- **Blok 7 se projektuje u skladu sa najboljim raspoloživim tehnikama za postrojenja za sagorijevanje – LCP BAT (*Best Available Techniques*) kao i u skladu sa Direktivom 2010/75/EU o industrijskim emisijama (IED) koji se odnosi na postrojenja za sagorijevanje (Poglavlje III, Annex V).**

## EKOLOŠKI AKSPEKTI ZAMJENSKOG BLOKA 7





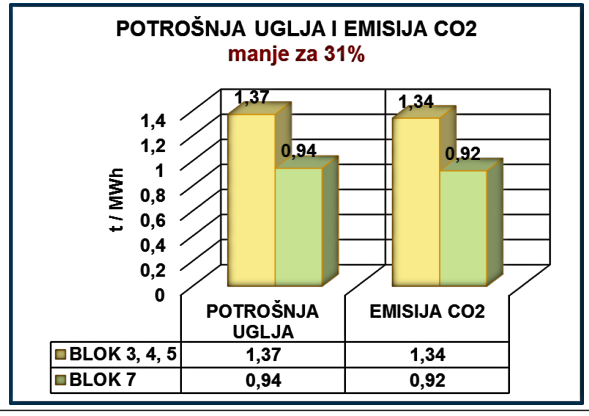


Neto stepen djelovanja
$\eta_{net}$ = 28% $\eta_{net}$ >42%
Specifična potrošnja kJ/kWh
12.857 8.571

| Proizvodnja na pragu 2806 GWh | = Za istu proizvodnju el. energije | = Proizvodnja na pragu 2806 GWh |
|---|---|---|
| Potrošnja uglja 574 t/h (1,37 t/MWh) | Potrošnja uglja manja za 31% | Potrošnja uglja 395 t/h (0,94 t/MWh) |
| Emisija $SO_2$ 18 t/MWh | Emisija $SO_2$ 48 X manja | Emisija $SO_2$ 0,37 t/MWh |
| Emisija NOx 1,6 t/MWh | Emisija NOx 2,5 X manja | Emisija NOx 0,64 t/MWh |
| Emisija prašine 0,27 t/MWh | Emisija prašine 7,3 X manja | Emisija prašine 0,037 t/MWh |

## Smanjenje potrošnje uglja i smanjenje emisije CO2 izgradnjom bloka 7

| Za predviđeni godišnji rad od 6720 sati blok 7 će u odnosu na stare blokove trošiti manja uglja za 1.206.508 t/god. | Za predviđeni godišnji rad od 6720 h blok 7 će u odnosu na stare blokove emitovati manje $CO_2$ za 1.178.520 t/god |
|---|---|




## Izgradnjom bloka 7 Grad Tuzla i TK dobijaju:

- Moderniji i efikasniji energetski kompleks
- Dugoročno okolinski prihvatljivo snabdijevanje toplinskom energijom priuštive cijene
- Značajno manje lokalno zagađenje i trajno rješavanje deponije šljake/pepela
- Mogućnost integracije OIE u SDG (biomasa, solar thermal)
- Image efikasne kogeneracije i regionalnog energetskog lidera
- Industrijsku intenzivnost
- Zadovoljstvo građana zbog poboljšanja okolinskog, ekonomskog i socijalnog aspekta

## ZAKLJUČCI - Ključni rizici za nove i zamjenske termoblokove u BiH

- Nacionalni plafon emisije $CO_2$ prema NECP. Termoblokovi na novim lokacijama povećavaju emisiju CO2, zamjenski blokovi u postojećim TE smanjuju emisiju CO2
- Visoka investicija, zatvaranje finansijske konstrukcije
- Troškovi u životnom vijeku (pogonski troškovi, cijena uglja, naknade, okolinski zahtjevi, takse na $CO_2$)
- Dugoročna održivost rudnika
- Struktura proizvodnog portfolia i uloga novih TE (broj radnih sati u budućem EES)
- Cijene električne energije: tržišta, (ne)ekonomske cijene domaćinstava, cijena taksi na emisije CO2
- En. zajednica i EU ciljevi (OIE, emisije, efikasnost, Takse $CO_2$, Coal phase-out…)
- Mogućnost visokoefikasnse kogeneracije
- Mogućnost korištenja biomase kao sekundarnog goriva

ACADEMY OF SCIENCES AND ARTS OF BOSNIA AND HERZEGOVINA (ANUBiH)

PUBLIC ENTERPRISE ELEKTROPRIVREDA OF BOSNIA AND HERZEGOVINA D.D. – SARAJEVO (EPBiH)

# RUDARSTVO BIH U ENERGETSKOJ TRANZICIJI


*dr. Edin Lapandić*
*dr. Omer Jukić*
*dr. Dimšo (Dušan) Milošević*
*dr. Boško Vuković*



NAUČNO-STRUČNO SAVJETOVANJE
**BUDUĆNOST POSTOJEĆIH I NOVIH TERMOELEKTRANA U BOSNI I HERCEGOVINI U ENERGETSKOJ TRANZICIJI**
21. novembar 2019. godine, Akademija nauka i umjetnosti Bosne i Hercegovine, Bistrik 7, 71000 Sarajevo


## ZNAČAJ UGLJA U PROIZVODNJI ELEKTRIČNE ENERGIJE

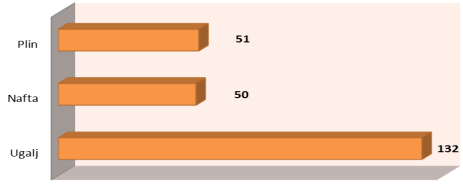
**Važnost uglja u svijetu je velika**

- 25% svih energetskih potreba podmiruje se iz uglja
- Drugi izvor primarne energije nakon nafte
- Glavni energent za proizvodnju električne energije



- Obezbjeđuje sigurnost dobave i balansira proizvodnju el. en.
- Ključna komponenta u proizvodnji čelika i betona
- Važan za privredni razvoj, podržava poslovanje, industriju i obezbjeđuje masovna zapošljavanja

**Vrijeme trajanja eksploatacije**

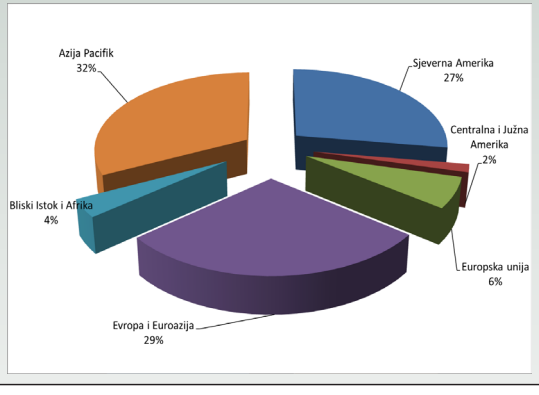



- Najrasprostranjenije gorivo s najdugotrajnijim rezervama
- Dokazane rezerve uglja iznose 1,055 milijardi tona

## REZERVE UGLJA U SVIJETU - REGIONALNA ZASTUPLJENOST

Prema dosadašnjim istraživanjima i dokazanim rezervama
- Rezerve uglja su raspodijeljene širom svijeta
- Ima ih na svakom kontinentu, u preko 70 zemalja

- **REZERVE NISU RAVNOMJERNO RASPOREĐENE**
- Gotovo sve rezerve su smještene u Sjevernoj Americi, Euroaziji i pacifičkom dijelu Azije što je ukupno 88%
- Najbogatije države sa ugljem u svijetu su: SAD, Rusija, Australija, Kina i Indija i one posjeduju 75,7% ukupnih svjetskih rezervi, gdje prednjače SAD sa 23,7%

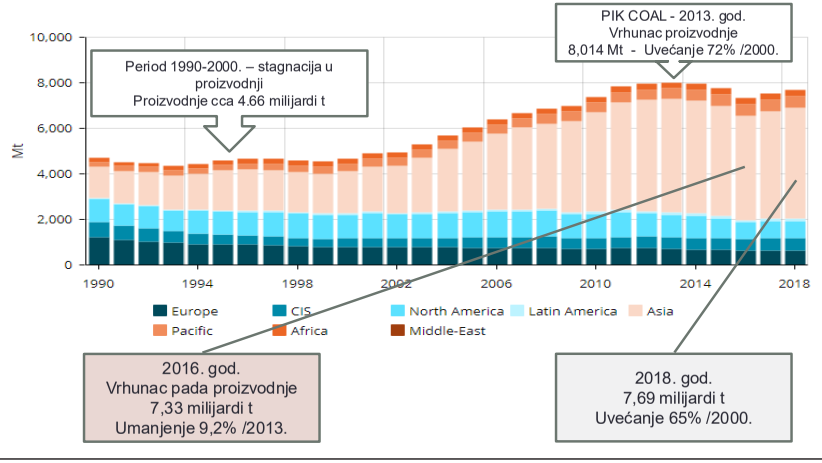



| R.b. | REGIJA | 000 M t | % |
|---|---|---|---|
| 1. | Sjeverna Amerika | 245.088 | 27,5 |
| 2. | Centralna i južna Amerika | 14.641 | 1,6 |
| 3. | Evropska unija | 56.082 | 6,3 |
| 4. | Europa i Euroazija | 254.456 | 28,5 |
| 5. | Bliski istok i Afrika | 32.936 | 3,7 |
| 6. | Azija pacifik | 288.323 | 32,3 |
| | **UKUPNO:** | 891.526 | 100 |

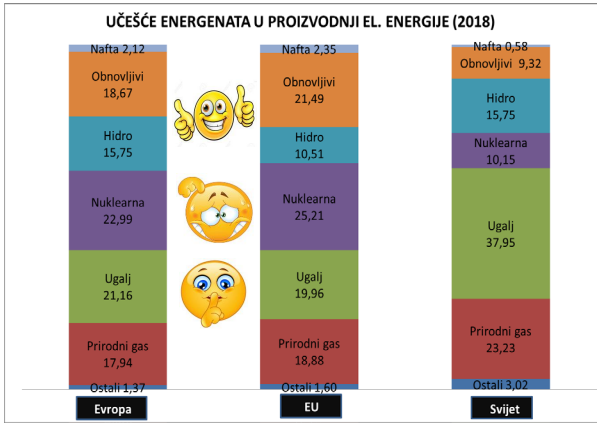
| R.b | Države | 2010 Mil. t | 2010 % | 2018 Mil. t | 2018 % |
|---|---|---|---|---|---|
| 1. | SAD | 237,3 | 27,6 | 250,219 | 23,7 |
| 2. | Rusija | 157,01 | 18,2 | 160,364 | 15,2 |
| 3. | Australija | 76,4 | 8,9 | 147,435 | 14,0 |
| 4. | Kina | 114,5 | 13,3 | 138,819 | 13,2 |
| 5. | Indija | 60,6 | 7,0 | 101,363 | 9,6 |
| 6. | Indonezija | 5,529 | 0,6 | 37,000 | 3,5 |
| 7. | Njemačka | 40,699 | 4,7 | 36,103 | 3,4 |
| 8. | Ukrajina | 33,873 | 3,9 | 34,375 | 3,3 |
| 9. | Poljska | 5,709 | 0,7 | 26,479 | 2,5 |
| 10. | Kazastan | 33,6 | 3,9 | 25,605 | 2,4 |
| 11. | **BiH** | **5,647** | **0,7** | **5,647** | **0,5** |
| 12. | Ostali | 90,076 | 10,6 | 91,373 | 8,7 |
| | **UKUPNO** | **860,94** | **100,0** | **1054,8** | **100** |

## PROIZVODNJA UGLJA PO REGIJAMA 1990-2018.

- Period 1990-2018. karaktriše stagnacija, uspon, pad i oporavak proizvodnje uglja
- Najbrže rastući globalni izvor energije
- Od početka trećeg milenija proizvodnja uglja je u velikom porastu (Kina, Indija, Indonezija, Australija, Japan, Južna Korea, Turska, Kazastan i dr.)



# UČEŠĆE ENERGENATA U PROIZVODNJI EL. EN. (2018)




**SVIJET**

- Fosilna goriva u proizvodnji el. energije učestvuju sa 64%.
- Od ukupno proizvedenih 26.614 TWh el. en. 17.086 TWh se proizvede iz fosilnih goriva.
- Ugalj je najvažniji resurs za proizvodnju električne energije na svjetskom nivou.

**Evropa i EU**

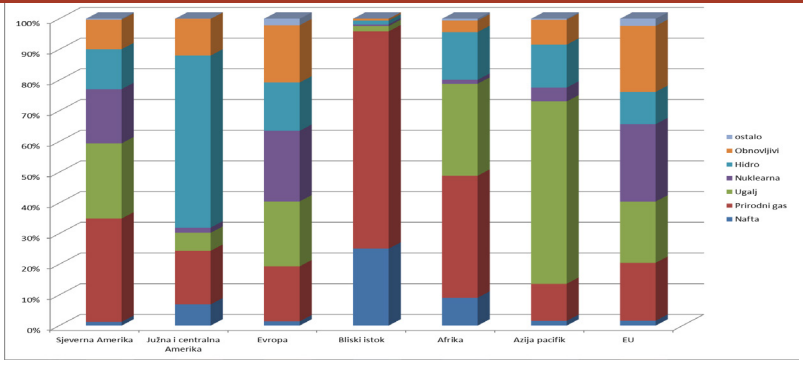
- Nisu toliko ovisne o proizvodnji el. energije iz fosilnih goriva.
- Učešće fosilnih goriva:
- **Evropa: 41,22%**
- **EU 41,19%**
- Na području Evrope i EU energenti ravnomjerno učestvuju u proizvodnji el energije.
- Nuklearna energija predstavlja okosnicu u proizvodnji el. en. u Evropi i EU.

| Energent | Terawat-sat | % |
|---|---|---|
| Nafta | 52,5 | 1,60 |
| Prirodni gas | 619,7 | 18,88 |
| Ugalj | 655,2 | 19,96 |
| Nuklearna en. | 827,4 | 25,21 |
| Hidro energija | 344,8 | 10,51 |
| Obnovljivi izvori | 705,5 | 21,49 |
| Ostalo | 77,1 | 2,35 |
| | 3.282,2 | 100,00 |

| Energent | Terawat-sat | % |
|---|---|---|
| Nafta | 56 | 1,37 |
| Prirodni gas | 731,3 | 17,94 |
| Ugalj | 862,7 | 21,16 |
| Nuklearna en. | 937,5 | 22,99 |
| Hidro energija | 642,1 | 15,75 |
| Obnovljivi izvori | 761,1 | 18,67 |
| Ostalo | 86,6 | 2,12 |
| | 4.077,3 | 100,00 |

| Energent | Terawat-sat | % |
|---|---|---|
| Nafta | 802,8 | 3,02 |
| Prirodni gas | 6.182,8 | 23,23 |
| Ugalj | 10.100,5 | 37,95 |
| Nuklearna en. | 2.701,4 | 10,15 |
| Hidro energija | 4.193,1 | 15,75 |
| Obnovljivi izvori | 2.480,4 | 9,32 |
| Ostalo | 153,8 | 0,58 |
| | 26.614,8 | 100,00 |

# UČEŠĆE ENERGENATA U PROIZVODNJI EL. EN. REGIJE (2018)




- Najrazvijenije i najmnogoljudnije regije u svijetu koriste ugalj kao dominantni energent u proizvodnji električne energija. Tu prednjače Azija, Sjeverna Amerika i dijelom Evropa.
- U Evropi zavisnost od uglja nije tako visoka kao što se generalno misli i niža je nego u drugim OECD ekonomijama. Nuklearna energija je glavni energent za proizvodnju el. energije.
- Prirodni gas je dominantno gorivo koje se koristi za proizvodnju električne energije u Sjevernoj Americi, Zajednici nezavisnih Država, Bliskom istoku i Africi.
- Južna i Centralna Amerika više od polovine svoje moći dobija od hidroelektrana.

**Regije za proizvodnju električne energije najviše koriste resurse koje im je priroda dodijelila.**

# Ovisnost regija i zemalja o proizvodnji el. en. iz uglja 2018.



**Najveći proizvođači el. energije iz uglja i njihova ovisnost**

| Rb. | Zemlja | TWh | % |
|---|---|---|---|
| 1. | Kina | 4.732,40 | 66,54 |
| 2. | SAD | 1.245,80 | 27,93 |
| 3. | Indija | 1.176,30 | 75,35 |
| 4. | Japan | 347,20 | 33,02 |
| 5. | Južna Koreja | 261,30 | 43,97 |
| 6. | Njemačka | 229,00 | 35,30 |
| 7. | Južna Afrika | 225,00 | 87,89 |
| 8. | Australija | 156,60 | 59,91 |
| 9. | Indonezija | 156,40 | 58,51 |
| 10. | Poljska | 134,70 | 79,19 |
| 11. | Taivan | 126,60 | 46,27 |
| 12. | Turska | 111,70 | 36,93 |
| 13. | Vietnam | 86,70 | 40,72 |
| 14. | Malezija | 74,10 | 44,00 |
| 15. | Kazastan | 70,20 | 65,55 |
| 16. | Mongolija | 4,80 | 95,1 |

Izvor: BP Statistical Review of World Energy, june 2019.

**Najveći ovisnici o proizvodnji el. en. iz uglja**
**Redoslijed po procentu ovisnosti**

| Rb. | Zemlja | % |
|---|---|---|
| 1. | Mongolija | 95,1 |
| 2. | Južna Afrika | 87,89 |
| 3. | Poljska | 79,19 |
| 4. | Indija | 75,35 |
| 5. | Kina | 66,54 |
| 6. | Kazastan | 65,55 |
| 7. | BiH | 61,29 |
| 8. | Australija | 59,91 |
| 9. | Indonezija | 58,51 |
| 10. | Taivan | 46,27 |
| 11. | Malezija | 44,00 |
| 12. | Južna Koreja | 43,97 |
| 13. | Vietnam | 40,72 |
| 14. | Turska | 36,93 |
| 15. | Njemačka | 35,30 |
| 16. | Japan | 33,02 |
| 17. | SAD | 27,93 |

Izvor: BP Statistical Review of World Energy, june 2019.

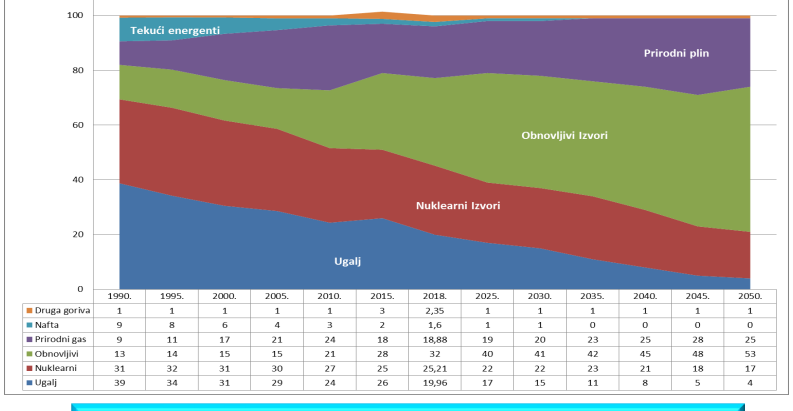
**Ovisnost regija o proizvodnji el. en. iz uglja 2018.**

| Rb. | Regija | TWh | % |
|---|---|---|---|
| 1. | Azija | 7.290,80 | 59,40 |
| 2. | Sjeverna Amerika | 1.334,30 | 24,49 |
| 3. | Evropa | 862,70 | 21,16 |
| 4. | Južna i centralna Amerika | 76,50 | 5,86 |
| 5. | EU | 655,20 | 19,96 |
| 6. | Afrika | 255,90 | 29,98 |
| 7. | Zajednica Nez. Država CIS | 259,00 | 18,27 |
| 8. | Bliski Istok | 21,30 | 1,72 |
| 9. | Svijet Ukupno | 10.100,50 | 37,95 |

Izvor: BP Statistical Review of World Energy, june 2019.

Najveće svjetske sile najviše ovise o proizvodnji el. energije iz uglja

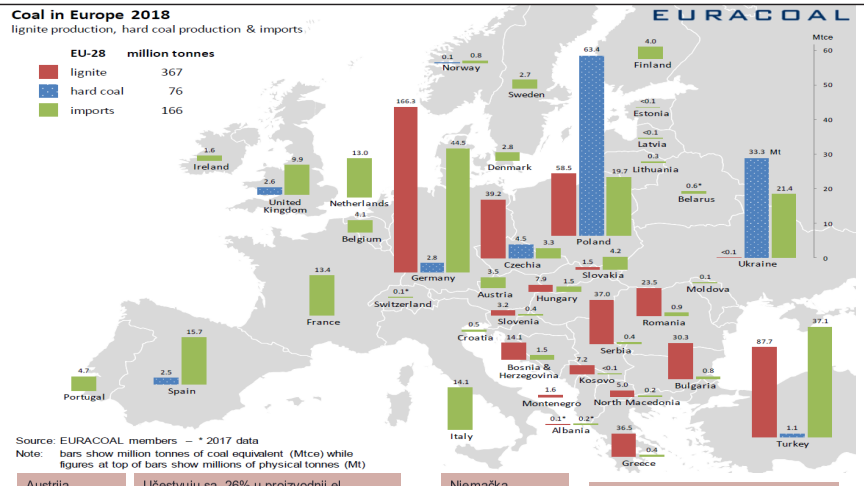
# PROJEKCIJE PROIZVODNJE EL. EN. EU DO 2050.




| | 1990. | 1995. | 2000. | 2005. | 2010. | 2015. | 2018. | 2025. | 2030. | 2035. | 2040. | 2045. | 2050. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Druga goriva | 1 | 1 | 1 | 1 | 1 | 3 | 2,35 | 1 | 1 | 1 | 1 | 1 | 1 |
| Nafta | 9 | 8 | 6 | 4 | 3 | 2 | 1,6 | 1 | 1 | 0 | 0 | 0 | 0 |
| Prirodni gas | 9 | 11 | 17 | 21 | 24 | 18 | 18,88 | 19 | 20 | 23 | 25 | 28 | 25 |
| Obnovljivi | 13 | 14 | 15 | 15 | 21 | 28 | 32 | 40 | 41 | 42 | 45 | 48 | 53 |
| Nuklearni | 31 | 32 | 31 | 30 | 27 | 25 | 25,21 | 22 | 22 | 23 | 21 | 18 | 17 |
| Ugalj | 39 | 34 | 31 | 29 | 24 | 26 | 19,96 | 17 | 15 | 11 | 8 | 5 | 4 |

**Plan dekarbonizacija EU – ciljevi do 2050.**

- Prirodni gas: povećanje na 25%
- Obnovljivi izvori: Solar, hidro i vjetar - povećanje na 53%
- Nuklearna energija: smanjenje na 17%
- Nafta: potpuno izbacivanje
- Ugalj: smanjenje na 4%




| | | |
|---|---|---|
| Austrija<br>Danska<br>Francuska,<br>Finska<br>Italija<br>Švedska<br>Holandija<br>Portugal i<br>Velika Britanija | Učestvuju sa 26% u proizvodnji el. energije iz uglja | Njemačka<br>Poljska<br>Češka Republika<br>Ukrajina<br>Turska<br>Srbija<br>Rumunija<br>Bugarska<br>Grčka<br>BiH |
| | Obavezale da će do 2030 postepeno ukinuti upotrebu uglja | |
| | Uglja se odriču one zemlje koje ga nemaju ili ga vrlo malo imaju. Navedene zemlje uvoze ugalj i njihove TE završavaju svoje životne vijekove do 2030. | |

Proizvođači i uvoznici i konzumentima

Neispunjavaju obaveze

Ovih 10 država spali 91% od svih količina uglja koji se spali u Evropi 758/833 miliona tona

# KO JE ŠTA URADIO?
## Energetsko-klimatski paket za 2020.



| | Države | 2010 | | | | 2018 | | | | 2018/2010 | 2018/2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lignniti | Kameni | Uvoz | Ukupno | Lignniti | Kameni | Uvoz | Ukupno | t | % |
| 1. | Njemačka | 169,4 | 12,9 | 45,1 | 227,4 | 166,3 | 2,8 | 44,5 | 213,6 | -13,8 | -8,2 |
| 2. | Poljska | 56,3 | 76,6 | 13,4 | 146,3 | 58,5 | 63,4 | 19,7 | 141,6 | -4,7 | -3,22 |
| 3. | Turska | 69 | 2,8 | 26,9 | 98,7 | 87,7 | 1,1 | 37,1 | 125,9 | 27,2 | 27,55 |
| 4. | Ukrajina | 0,2 | 54,4 | 15,6 | 70,2 | 0,1 | 33,3 | 21,4 | 54,8 | -15,4 | -21,94 |
| 5. | Češka Republika | 43,8 | 11,4 | 1,9 | 57,1 | 39,2 | 4,5 | 33 | 76,7 | 19,6 | 34,22 |
| 6. | Grčka | 56,5 | 0 | 0,6 | 57,1 | 36,5 | 0 | 0,4 | 36,9 | -20,2 | -35,38 |
| 7. | Srbija | 37,2 | 0 | 1,2 | 38,4 | 37 | 0 | 0,4 | 37,4 | -1 | -2,61 |
| 8. | Bugarska | 27,2 | 3 | 3,5 | 33,7 | 30,3 | 0 | 0,8 | 31,1 | -2,6 | -7,72 |
| 9. | Rumunija | 27 | 2,2 | 1 | 30,2 | 23,5 | 0 | 0,9 | 24,4 | -5,8 | -19,21 |
| 10. | BiH | 11 | 0 | 0,7 | 11,7 | 14,1 | 0 | 1,5 | 15,6 | 3,9 | 33,33 |
| | UKUPNO | 497,6 | 163,3 | 109,9 | 770,8 | 493,2 | 105,1 | 159,7 | 758,0 | | |

Izvor: EUROCOAL members - 20188 data

- Ukupno smanjenje: 12,8 miliona tona ili 1,66%
- Ligniti: smanjenje za 4,4 miliona tona ili 0,8%
- Kameni: smanjenje za 58,2 miliona tona ili 35%
- Uvoz : povećanje 49,8 miliona tona ili 45,31%

**KONSTATACIJA**

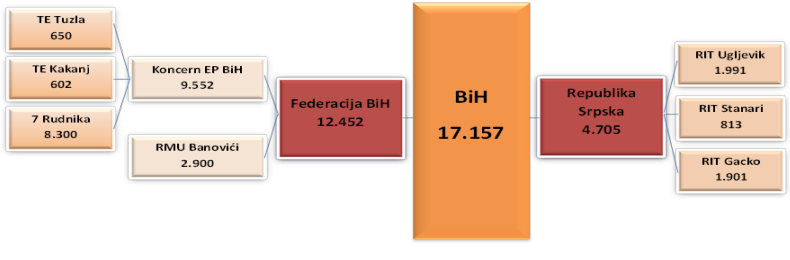
**NAJVEĆI PROIZVOĐAČI I NAJVREĆI POTROŠAČI NE RADE DOVOLJNO, ZAPRAVO, DO SADA NISU NIŠTA URADILI**

**Je li opravdan tako veliki pritisak na BiH i zemlje zapadnog bakana?**

# RUDARSTVO U BIH

- U sistemu proizvodnje el. energije na nivou BiH, ugalj ima stratešku i nezamjenjivu ulogu.
- Temeljni energent za proizvodnju električne energije u BiH: na nivou BiH učestvuje sa 60%, u FBIH sa 80% a u RS 65%.
- Najveći i najznačajniji domaći energetski resurs snabdijeva 5 termoelektrana, 2 u FBiH i 3 u RS, ukupno11 termo-blokova.
- Konzumenti: termoelektrane elektroprivrednih kompanija BiH, industrija, široka potrošnje i izvoz.

**SEKTOR PROIZVODNJE ELEKTRIČNE ENERGIJE IZ UGLJA – BROJ UPOSLENIH**




Hrvatska 11.000 ukupno uposlenih u EE Sektoru

Republika Srbija 24.000 uposlenih samo u rudarstvu

EU ukupno 240.000 180.000 u rudarstvu 60.000 u TE

BIH 27.224 Ukupno uposlenih u EES FBiH 15.630, RS 9.465, HZ HB 2.129

# Rezerve uglja u BiH

| Rezerve uglja BiH | | | | | | |
|---|---|---|---|---|---|---|
| R. b. | Rudnik | REZERVE (000 t) | | | | |
| | | Bilansne | Vanbilansne | Potencijalne | Ukupne | Eksploat. |
| | | $(A+B+C_1)$ | $(A+B+C_1)$ | $(C_2+D_1+D_2)$ | geološke | $(A+B+C_1)$ |
| Ukupno ligniti BiH | | 1.437.635 | 412.103 | 1.386.653 | 3.236.391 | 1.004.593 |
| Ukupno mrki ugalj BiH | | 1.181.009 | 207.031 | 1.150.827 | 2.538.867 | 896.697 |
| Ukupno BiH | | 2.618.644 | 619.134 | 2.537.480 | 5.775.258 | 1.901.290 |

Izvor: Studija energetskog sektora u BiH (2008.); Podaci sa Rudnika

Prema važećoj dokumentaciji koja potvrđuje i obrađuje rezerve i kvalit ugljeva u BiH

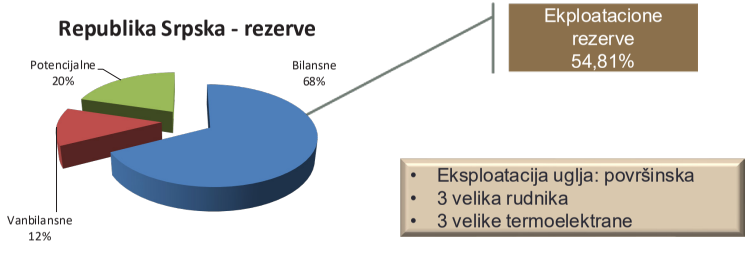
- Mrki ugljevi su relativno dobrog kvaliteta sa prosječnom toplotnom vrijednošću oko 16.750 [kJ/kg], ali sadrže znatne količine ukupnog sumpora (2-6%), pepela (10-45%) i vlage (10-25%).
- Ligniti su visokokvalitetni, čisti, toplotne vrijednosti; 7.500-12.600 [kJ/kg], 0,2-1,0% ukupnog sumpora, rijetko više, pepela 5-9% i vlage 35-53%.

# REZERVE UGLJA I PROIZVODNJA REPUBLIKA SRPSKA

**Rezerve uglja Republika Srpska**

| R. b. | Rudnik | REZERVE (000 t) Bilansne (A+B+C1) | Vanbilansne (A+B+C1) | Potencijalne (C2+D1+D2) | Ukupne geološke | Eksploat. (A+B+C1) | Hd (GJ/t | Vlaga (%) | Pepeo (%) | Sumpor (%) | Proizvodnja (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Rudnik Ugljevik (M) | 264.835 | 17.854 | 114.535 | 397.224 | 199.732 | 12,502 | 31,92 | 19,24 | 4,45 | 2.027.457 |
| 2. | Rudnik Stanari (L) | 107.221 | 31.842 | 9.761 | 148.824 | 73.271 | 9,646 | 50,75 | 5,74 | 0,17 | 2.450.870 |
| 3. | Rudnik Gacko (L) | 278.540 | 56.317 | 37.380 | 372.237 | 253.471 | 10,174 | 37,97 | 15,68 | 1,55 | 2.715.904 |
| 4. | Rudnik Miljevina (M) | 21.200 | 15.800 | 40.100 | 77.100 | 19.080 | 11,7-14,8 | 24,9 | 24,83 | 2,2 | 70.355 |
| 5. | Rudnik Mezgraja (M) | N/P | N/P | N/P | N/P | N/P | N/P | N/P | N/P | N/P | 140.998 |
| | **Ukupno lignit RS** | **385.761** | **88.159** | **47.141** | **521.061** | **326.742** | | | | | **5.166.774** |
| | **Ukupno mrki ugalj RS** | **286.035** | **33.654** | **154.635** | **474.324** | **218.812** | | | | | **2.238.810** |
| | **Ukupno RS** | **671.796** | **121.813** | **201.776** | **995.385** | **545.554** | | | | | **7.405.584** |

Izvor: Studija energetskog sektora u BiH (2008.) ; Podaci sa Rudnika



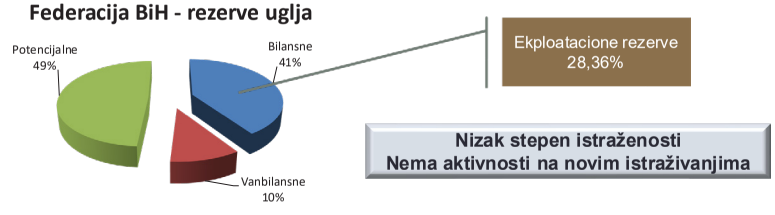

- Eksploatacija uglja: površinska
- 3 velika rudnika
- 3 velike termoelektrane

# REZERVE UGLJA I PROIZVODNJA FEDERACIJA BIH

**Rezerve uglja Federacija Bosne i Hercegovine**

| R. b. | Rudnik | REZERVE (000 t) Bilansne (A+B+C1) | Vanbilansne (A+B+C1) | Potencijalne (C2+D1+D2) | Ukupne geološke | Eksploat. (A+B+C1) | Hd (GJ/t | Vlaga (%) | Pepeo (%) | Sumpor (%) | Proizvodnja (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | RU Kreka (L) | 743.954 | 322.833 | 59.407 | 1.126.194 | 456.008 | 11,31 | 38,7 | 13,06 | 0,61 | 2.400.000 |
| 2. | RMU Banovići (M) | 194.085 | 13.935 | 0 | 208.020 | 162.429 | 16,18 | 16,09 | 24,14 | 1,74 | 1.500.000 |
| 3. | RMU Đurđevik (M) | 60.183 | 4.963 | 0 | 65.146 | 54.524 | 17,95 | 9,42 | 25,77 | 2,3 | 570.000 |
| 4. | RMU Kakanj (M) | 256.536 | 56.525 | 127.604 | 440.665 | 204.839 | 12,5-16,07 | 5,7-9,16 | 35,49-42,75 | 1,4-3,85 | 1.170.000 |
| 5. | RMU Breza (M) | 49.244 | 23.928 | 0 | 73.172 | 28.098 | 14428 | 6,61 | 30,99 | 2,54 | 600.000 |
| 6. | RMU Zenica (M) | 179.843 | 59.931 | 721.369 | 961.143 | 131.800 | 17,619 | 12,58 | 22,32 | 3,65 | 500.000 |
| 7. | RMU Bila (M) | 26.808 | 10.373 | 25.354 | 62.535 | 16.091 | 14503 | 15,84 | 24,65 | 4,69 | 145.000 |
| 8. | RU Gračanica (L) | 10.657 | 0 | 0 | 10.657 | 10.657 | 10,746 | 32,43 | 17,06 | 2,95 | 255.000 |
| 9. | Rudnik (L) | 76.201 | 1.111 | 0 | 77.312 | 68.528 | 11 | 39 | 13 | 2,23 | nema proiz. |
| | Tušnica (M) | 16.274 | 0 | 1.865 | 18.139 | 11.433 | 15 | 16,5 | 18 | 4 | nema proiz. |
| 10. | RU Kamengrad (M) | 112.001 | 3.722 | 120.000 | 235.723 | 68.671 | 13,003 | 22,6 | 24,19 | 4,08 | nema proiz. |
| 11. | Bugojno (L) | 14.651 | 0 | 1.280.105 | 1.294.756 | 12.893 | 11,36 | 3288 | 19,43 | | nema proiz. |
| 12. | Kongora (L) | 206.411 | 0 | 0 | 206.411 | 129.765 | 7,38 | 35,06 | 27,5 | 1,25 | nema proiz. |
| | **Ukupno lignit F BiH** | **1.051.874** | **323.944** | **1.339.512** | **2.715.330** | **677.851** | | | | | **2.655.000** |
| | **Ukupno mrki ugalj F BiH** | **894.974** | **173.377** | **996.192** | **2.064.543** | **677.885** | | | | | **4.485.000** |
| | **Ukupno F BiH** | **1.946.848** | **497.321** | **2.335.704** | **4.779.873** | **1.355.736** | | | | | **7.140.000** |

Izvor: Studija energetskog sektora u BiH (2008.)




**Nizak stepen istraženosti**
**Nema aktivnosti na novim istraživanjima**

# ENERGETSKA TRANZICIJA BIH

- Uvažavajući navedeno, rezerve uglja, ovisnost o uglju i nespremnost da brzo izgradi kapacitete iz obnovljivih izvora, BiH u tranzicijskom periodu koji će trajati najmanje 30 a vjerovatno 40 godina, morat će koristiti termoelektrane na ugalj kako bi obezbijedile prijeko potrebnu el. energiju za domaćinstvo i industriju.
- Nakon ovog perioda dominacija u proizvodnji el. energije će biti prepuštena obnovljivim izvorima.
- EU do 2050 planira ugalj kao energent za proizvodnju el. en. svesti na svega 4%, BiH to neće postići 2050. zbog ekonomske nemoći ali 2060. će biti u poziciji da ispuni obaveze iz Energetsko-klimatskog plana.
- Uvažavajući Bosanskohercegovačku slabu ekonomiji i poredeći je sa zemljama EU, plan je više nego dobar i prije svega realan.
- Zatvaranjem starih blokova i izgradnjom zamjenskih koji će biti izgrađeni po najstrožijim standardima BAT-a i izgradnjom kapaciteta za proizvodnju el. en iz obnovljivih izvira, BiH će 2060. godine stati rame uz rame sa ostalim zemljama EU u borbi protiv klimatskih promjena i očuvanja naše planete.
- U prezentiranom materijalu vidi se da i najmoćnije ekonomije propuštaju ispuniti obaveze proistekle iz EKP, što znači da je proces tranzicije težak put u kome će se morati tolerisati vremenski rokovi.
- BiH je jedna od rijetkih zemalja koja je ispunila obaveze u pogledu samnjenja emisija CO2 po osnovu EKP do 2020. iako nije bila obavezna.
- Emisija CO2 u odnosu na baznu 1990. smanjena je za 28%.

## ZNAČAJ RUDARSTVA

a) Rudarstvo je značajan segment privrede BiH, uz činjenicu da je ugalj jedan od najznačajnijih domaćih resursa (termoelektrane na ugalj učestvuju sa cca 60% u proizvodnji električne energije u BiH).

b) Ugalj ima značajnu ulogu za sigurnost i ekonomsku efikasnost mnogih geoprostora, pa tako i našeg, posebno u oblasti proizvodnje elektroenergije. Procjenjuje se da će u narednih 30-tak godina termoelektrane na ugalj biti ekonomski atraktivnije, pogotovo u zemljama s velikim rezervama uglja. Neophodno je kontinuirano unapređivati tehnologiju proizvodnje uglja, ali i tehnologiju dobivanja „čistog“ uglja kako bi se dobio ugalj optimalnog kvaliteta i zaštitio okoliš.

c) Potpuno korištenje instaliranih kapaciteta termoelektrana omogućava rad rudnika uglja koji su u dobroj mjeri zapušteni (nedovoljno istražena ležišta, nepripremljeni proizvodni kapaciteti, visoko amortizirana proizvodna i prateća oprema ...).

d) Potrebno je utvrditi da li ćemo ugalj tretirati energentom prihvatljivog kvaliteta, jer je u javnosti puno distanciranja od uglja kao energenta (zbog uticaja na okoliš i stavova EU). Naglašavamo da možemo koristiti ugalj kao energent (zbog stanja industrije i sl.) i sigurno ispuniti uvjete iz Kyota i Pariškog sporazuma iz 2016. godine, koje smo ratificirali i prihvatili kao međunarodnu obavezu BiH.

## RESTRUKTURIRANJE RUDNIKA UGLJA

### Osnovni zadaci

a) U rudnicima uglja je potrebno restrukturirati tehnologiju dobivanja uglja, proizvodnu i prateću opremu, radnu snagu.

b) Zbog nedovoljno istraženih ležišta u rudnicima uglja je, u entitetskim JP koja upravljaju rudnicima, potrebno oformiti Sektore za istražna bušenja/radove u rudnicima (postiglo bi se znatno pojeftinjenje ovih vrlo značajnih rudarskih radova, nego da ih svaki rudnik pojedinačno finansira - jedna oprema za sve rudnike).

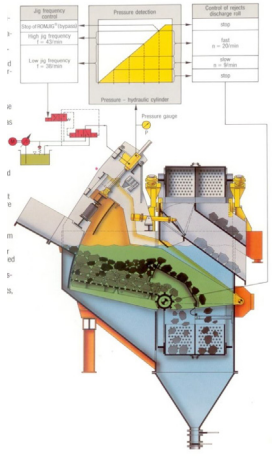
## Čišćenje uglja – priprema uglja za sagorijevanje u kotlovima termoelektrana (ekološki i ekonomski faktor)

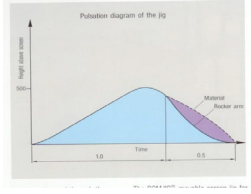
a) Svaki rudnik ima separaciju uglja, nažalost zapuštenu u svakom pogledu (svaka sa tehnologijom iz vremena u kojem je izgrađena, ... bez investiranja, bez uvođenja novih tehnologija). Dugi niz godina nije bilo investiranja u nabavku opreme za unapređenje tehnologije dobivanja „čistog“ uglja (bitan uslov za redukciju $SO_2$, $NO_x$ i prašine pri sagorijevanju ovih ugljeva u kotlovima termoelektrana) kako bi se dobio ugalj optimalnog kvaliteta i zaštitio okoliš. Naravno, postoje novije tehnologije i oprema za čišćenje uglja (izdvajanje jalovine).

b) Dugogodišnja eksploatacija uglja u rudnicima za potrebe termoelektrana neminovno vodi ka postepenom i stalnom padu kvaliteta uglja, odnosno otkopavanju uglja slabije toplotne vrijednosti. Rezerve kvalitetnog uglja su, uglavnom, otkopane, pa je poboljšanje kvaliteta uglja koji se trenutno otkopava, zbog niza razloga, neminovnost za sve učesnike u lancu otkopavanja, pripreme, transporta i konverzije njegove toplotne energije u električnu.

c) Korist takvog pristupa rješavanju problema poboljšanja kvaliteta rovnog uglja za potrebe termoelektrana je višestruka. Izbjegavaju se troškovi nepotrebnog transporta jalovine do termoelektrana, oštećenja kotlova u termoelektranama (ložišta, ekranske cijevi), a ni ekološki faktor ne treba zanemariti (čistiji ugalj - bolje sagorijevanje u kotlovima - produkti sagorijevanja manje zagađuju okoliš).

## ROMJIG taložnik s pokretnim sitom (za površinsku eksploataciju uglja)



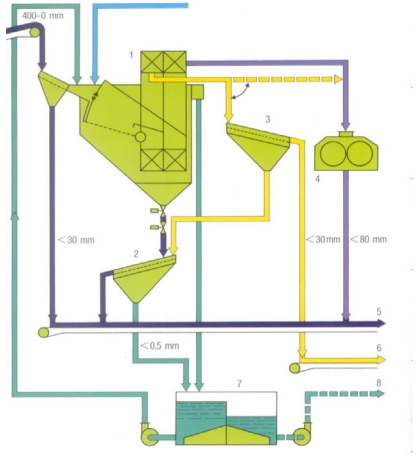



Dijagram pulsacije uzorka materijala

Taložnik sa pokretnim sitom je mašina namijenjena za primarno separisanje jalovine od krupnog rovnog uglja veličine 400-30 mm. Vremenom je primjenjivost mašine proširena, između ostalog, na pripremu očišćenog uglja i ćišćenje šljunka krupnog zrna.

Prvi ROMJIG taložnik s pokretnim sitom je prvi puta uspješno testiran u teškim uslovima tokom kontinuiranog rada u njemačkom rudniku uglja Emil Mayrisch. ROMJIG nove generacije sa taložnikom širokim 2,0 m separiše jalovinu na čistoću od više od 95% po težini (+1,9 kg/dm$^3$) čak i u uslovima velikih promjena brzine punjenja rovnim ugljem i pri velikim fluktuacijama u udjelu jalovine u punjenju. Težinsko iskorištenje jalovine je preko 90%.

## Shema separacije primarne jalovine u ROMJIG postrojenju za površinsku eksploataciju




LEGENDA:

- Rovni ugalj
- Ugalj i međuproizvod
- Jalovina
- Reciklirana voda
- Svježa voda

1. ROMJIG taložnik sa pokretnim sitom
2. Sito za cijeđenje
3. Sito za klasiranje
4. Drobilica s valjcima
5. Prema bunkeru za rovni ugalj
6. Prema odlagalištu jalovine
7. Rezervoar za recikliranu vodu
8. Prema ispirači

Jalovina separisana u ROMJIG postrojenju se može odlagati na odlagalištima jalovine na površinskim kopovima.

ROMJIG taložnik sa pokretnim sitom se u mnogim zemljama može iskoristiti za pripremu očišćenog uglja koji se prije spaljivao kao rovni ugalj. Sa ROMJIG procesom se štede specifični troškovi transporta do termoelektrane. Termoelektrani se dostavlja sirovina koja ima povećanu i konstantnu toplotnu vrijednost. Također se smanjuje i habanje kotlova.

Rovni ugalj sa udjelom pepela od 45 % koji se eksploatiše na površinskom kopu u Bini, Indija, se u centralnom sistemu za drobljenje drobi na veličinu od minus 400 mm i prosijava na 30 mm. Konačna - laka frakcija koji sadrži 31 % pepela i rovni ugalj sa 41 % pepela se termoelektrani dostavljaju kao miješani proizvod (očišćeni ugalj) sa udjelom pepela od 34%.

| PROIZVODI | TEŽINA [% po težini] | PEPEO [%] |
|---|---|---|
| Laka frakcija [400-30 mm, – 1,9 kg/m$^3$] | 53,0 | 31,1 |
| Rovni ugalj [30-0 mm] | 24,0 | 41,0 |
| Očišćeni ugalj [400-0 mm] | 77,0 | 34,1 |
| Teška frakcija - jalovina [400-30 mm, + 1,9 kg/m$^3$] | 23,0 | 81,0 |
| Rovni ugalj [400-0 mm] | 100,0 | 44,9 |



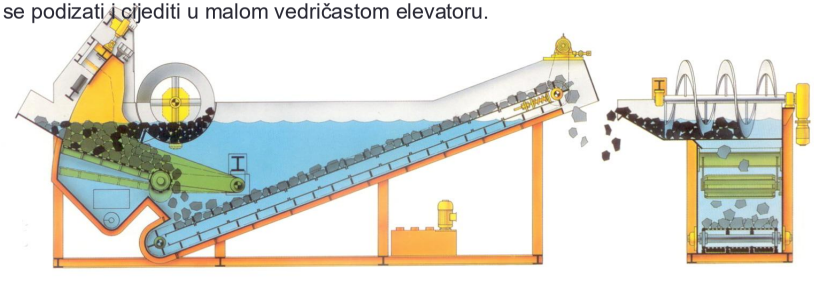
Shema proizvodnje očišćenog uglja ROMJIG procesom

**Rezultat ROMJIG procesa je ugalj sa konstantnom ukupnom koncentracijom pepela, što omogućava optimalan rad termoelektrana.**

## ROMJIG taložnik za podzemnu eksploataciju uglja

Postoji i pljosnata verzija ROMJIG postrojenja koja je namijenjena podzemnoj eksploataciji uglja. Ova verzija je opremljena trakastim transporterom koji se koristi za odvoz jalovine. Trakasti transporter povlači jalovinu iz vodene kupke i u isto vrijeme je cijedi. Laka frakcija se sakuplja u žlijebu na preljevu i ispušta preko velikog pužnog (spiralnog) transportera.

Očišćeni ugalj se iz korita pužnog transportera povlači uz pomoć puža (spirale) i može se podizati i cijediti u malom vedričastom elevatoru.



## XRT - tehnološko rješenje oplemenjivanja uglja (metoda X-Ray Technology)

Predloženo je na osnovu sprovedenih laboratorijskih, poluindustrijskih i industrijskih ispitivanja mogućnosti oplemenjivanja uglja iz krovinske ugljene serije i dijelova Polja C. Usvojena metoda XRT (X-Ray Technology) senzorske separacije zasniva se na karakteristici materijala da u funkciji atomske gustine, u većoj ili manjoj mjeri, propušta rendgenske (X) zrake. Kako bi se za odgovarajuću supstancu omogućila separacija po osnovu karkateristične adsorpcije (ili propusnosti), analizira se propusnost pri emisiji X zraka visoke i niske energije. Razlika u propusnosti ovih zračenja predstavlja kriterijum na osnovu koga se vrši rekogniziranje materije. Efekti primjene tehnologije selektivne eksploatacije uglja su nedovoljni za smanjenje gubitaka i razblaženja. Dok je pitanje gubitaka vezano za stepen iskorišćenja raspoloživih resursa, pojava razblaženja utiče na kvalitet proizvoda eksploatacije - „rovnog uglja“. Probe uglja (industrijsko ispitivanje) oplemenjivanja su izvršene na X-ray senzorskom uređaju za sortiranje STEINERT XSS 100 (Njemačka).



## Rezultati oplemenjivanja:

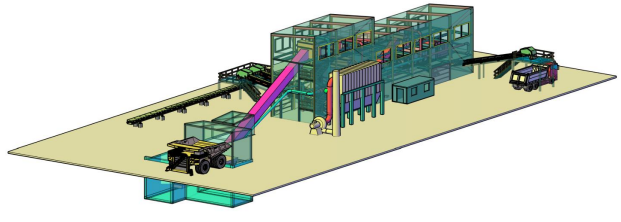


Prečišćeni ugalj



Jalovina

## Šematski prikaz postrojenja za prečišćavanje uglja:

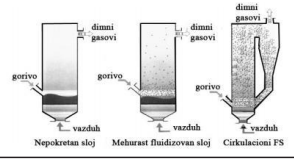


# Kvalitet uglja i sagorijevanje u fluidnom kotlu TE

Kvalitet uglja koji se danas otkopava u našim rudnicima je zadovoljavajući za sagorijevanje uglja u cirkulacionom fluidiziranom sloju (fluidni kotlovi - CFB). Fluidni kotlovi ispunjavaju sve limite emisija propisanih ekološkim standardima EU, niske emisije $SO_2$ - krečnjak je efikasan sorbent sumpora u temperaturnom rasponu od 815°C do 925°C, efikasnost odstranjivanja $SO_2$ u iznosu od 95% i više, niske emisije $NO_X$ - niske temperature u ložištu od 850°C do 890°C, uz dovod zraka u ložište, rezultiraju veoma niskim emisijama $NO_X$. Osim navedenog, CFB tehnologija je čista tehnologija za sagorijevanje uglja uz visoku efikasnost sagorijevanja.

Fluidni kotlovi - CFB se mogu instalirati i u postojećim kotlovskim postrojenjima TE ili rekonstruirati ~~postojeći kotlovi (pa i oni kojima je istekao radni vijek). U tom kontekst~~u bi trebalo izraditi odgovarajuće Studije izvodljivosti.

Kako već imamo izgrađene sisteme (ili izrađene studije) za zagrijavanje gradova iz TE „Tuzla“ i TE „Kakanj“ (sa započetom izgradnjom bloka VII u TE „Tuzla“ i predviđenom izgradnjom bloka VIII u TE „Kakanj“) mora se reći da bez povećanja i stabilne proizvodnje u rudnicima, neće biti dovoljno uglja za ove blokove, a neće biti ni predviđenog zagrijavanja gradova. Ovo je napomena u kontekstu traženja rješenja za čistiji zrak u našim gradovima.




# RUDARSTVO U FUNKCIJI OBNOVE I TEHNOLOŠKOG RAZVOJA PRIVREDE, ZAPOŠLJAVANJA

## Uvod

Iz rudarstva su se razvijali razni zanati i proizvodnja opreme i alata za rad u rudarstvu, nakon toga njihova industrijska proizvodnja i razvoj, čime je jačala podrška sigurnom i efikasnom radu i razvoju rudarstva/rudnika, što je, u sadašnjim okolnostima, bitno za obnovu i tehnološki razvoj domaće mašinogradnje, elektrogradnje, drvne industrije ...

## Funkcionalne oblasti istraživanja u energetskom sektoru

U ovom kontekstu je potrebno predvidjeti istraživanja u iskorištavanju nus produkata proizvodnje uglja i električne energije (npr. u termoelektranama šljaka i elektrofilterski pepeo - produkt sagorijevanja uglja u kotlovima kojeg zadržavaju elektrofilteri, u rudnicima uglja tzv „halda“ - izgorjela ili oksidirana jalovina iz uglja na odlagalištima ... prije rata su vršena istraživanja i dobijeni pozitivni rezultati ... moguće od svega navedenog dobiti građevinske materijale i iz njih gotove proizvode). Danas se elektrofilterski pepeo koristi u proizvodnji cementa. ... Ovako dobijamo nove resurse, efikasno upravljanje otpadom, pozitivan uticaj na okoliš, dobre ekonomske efekte, nova radna mjesta.

Dakle, ovdje je riječ o naučnim i razvojnim istraživanjima u sferi ekonomskih, razvojnih i socijalnih politika.

# Rudarstvo i ekologija

Napomena: Odnos prema ekologiji u rudarstvu nije zadovaljavajući, van normi predviđenim zakonim i podzakonskim aktima-propisima u ovoj oblasti. Ovom problematikom se najviše bave pojedinci – entuzijasti.

## Zaštita od buke

Visok nivo buke je glavni uzrok smanjenja kvaliteta života u urbanim sredinama i na područjima uz izvore buke (industrijska postrojenja, saobraćaj i sl.). Smanjenje nivoa buke u urbanim sredinama je bitan ekološki zahtjev prema kojemu se provode mjere zaštite u svim evropskim zemljama, pa tako i kod nas.

## Naseljeno mjesto zaštićeno od buke aluminijskom barijerom (aluminijskim panelima)

Izvor buke: pretovar uglja sa transportne trake u željeznički vagon



Izgled pretovarnog bunkera prije izgradnje barijere



Izgled pretovarnog bunkera poslije izgradnje barijere

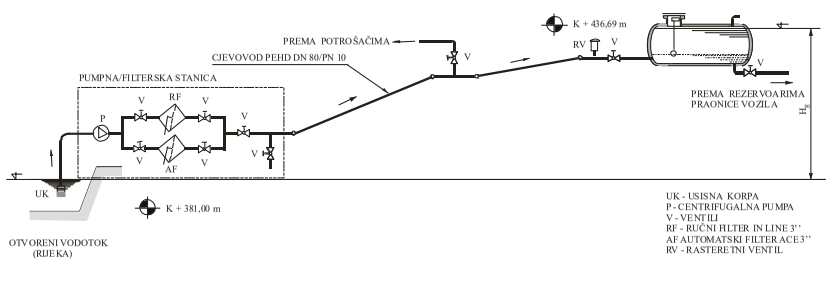


Utovar uglja u željeznički vagon

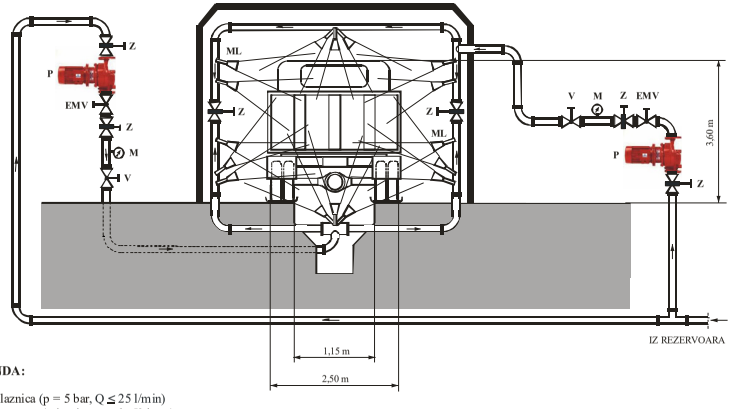
# Prečišćavanje otpadnih voda iz separacija uglja i sa površinskih kopova

Otpadne vode iz sistêmâ (postrojênjâ) za preradu uglja se gravitacionim tokom, podzemnim ili otvorenim odvodnim kanalima, usmjeravaju direktno u otvorene vodotokove. Kako se u otpadnoj vodi nalaze značajne količine sitnog uglja i zanemarljive količine čestica magnetita, nameće se potreba da se iz ekoloških (sprečavanje zagađenja otvorenih vodotokova) i komercijalnih razloga (sitni ugalj iz otpadne vode se nakon prirodnog sušenja i eliminiranja grube vlage može prodati) vrši prečišćavanje otpadnih voda nekim od poznatih načina za prečišćavanje.

## Vodosnabdijevanje – industrijski vodovod:



## Automatizirana praonica teretnih vozila




**LEGENDA:**

**ML** - Mlaznica (p = 5 bar, Q ≤ 25 l/min)
**M** - Manometar (mjerni opseg do 50 bara)
**Z** - Zaporni zasun (DN 100, PN 16)
**EMV** - Elektromagnetni ventil (DN 100, PN 16, Siemens)
**P** - Pumpni agregat (Q = 105 m³/h, p = 3 bar, tip: WILO MVI)
**V** - Ručni regulacioni ventil (DN 100, PN 16)
**L** = 9,50 m - max. dužina teretnog vozila

Shema praonice teretnih vozila



Pumpna / filterska stanica industrijskog vodovoda



Pumpna stanica automatizirane praonice teretnih vozila



Izgled praonice



## Pranje vozila:



Ulazak vozila u praonicu



Izlazak vozila iz praonice



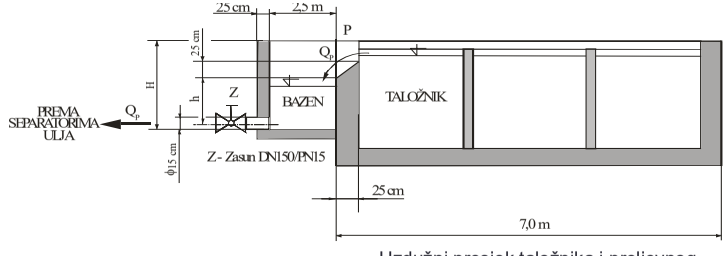
Pranje vozila danju



Pranje vozila noću

## Prečišćavanje otpadnih voda:

### Izdvajanje ulja i naftnih derivata iz otpadnih voda:

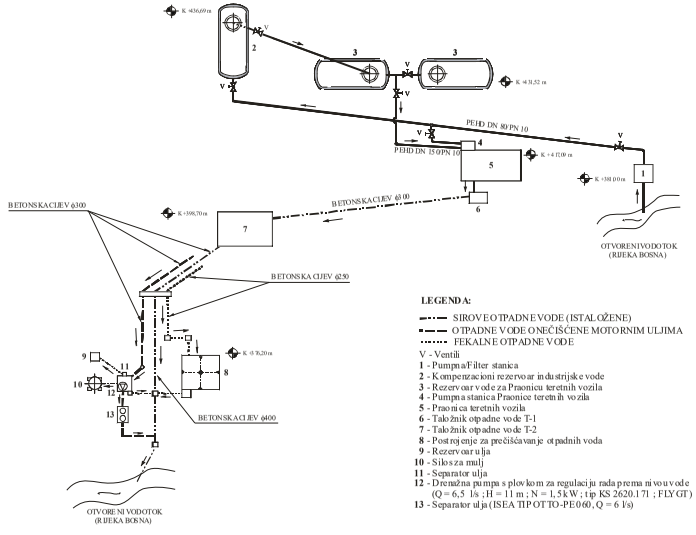



Uzdužni presjek taložnika i preljevnog bazena otpadnih voda



Izgled separatora ulja i naftnih derivata ugrađenog u zemlju (paralelnim spajanjem više separatora je moguće dobiti željeni kapacitet)

## Shema optimalnog korištenja vode iz otvorenog vodotoka:




## Društveni značaj rudnika

Rudnici uglja su, u većini slučajeva, dominantna privredna društva u općinama u kojim egzistiraju i kao takva imaju presudan utjecaj na razvoj lokalne privrede, zapošljavanje i životni standard stanovništva, socijalnu sliku lokalne zajednice općenito. Od njih ovisi komunalna djelatnost, trgovina, ugostiteljstvo. Rudnici su sponzori sportskih klubova, institucija kulture ... Stanje u Rudnicima uglja se u znatnoj mjeri odražava na kvalitet života stanovništva općina u kojim egzistiraju. Navedene konstatacije ukazuju na to da ekonomski položaj Rudnika uglja ima stanovite implikacije na sve društvene djelatnosti
u njihovim općinama.

## ZAKLJUČCI

- Ugalj je najvažniji energent za proizvodnju električne energije. Učešće uglja u proizvodnju el. en. je: Svijet 38%, Evropa 21,6%, EU 20%, BiH 60%.
- EU je napravila plan proizvodnje el. en. do 2050. „gotovo bez uglja“ (4%). Dok je to na svjetskom nivou izgleda nemoguće napraviti.
- Planovi tranzicije u kojoj se ugalj planira izgurati iz upotrebe ne idu planiranom dinamikom. Ovo daje pravo ugljarskoj industriji da se nada da njeno istrebljenje nije tako blizu i da će i u budućnosti biti jak igrač u polju energetike.
- Obnovljivi izvori energije neće moći podmiriti potrebe za energijom u narednim desetljećima. Razlog je više nego jasan: u sistemu mora postojati energent koji će osigurati balans proizvodnje električne energije. Sada su to elektrane na ugalj i nuklearne elektrane.
- Kada je u pitanju BIH, ugalj je jedan od najznačajnijih domaćih energetskih resursa koji tradicionalno omogućava upošljavanje velikog broja radnika i čini Bosnu i Hercegovinu energetski neovisnom.
- BiH da bi očuvala energetsku neovisnost, sačuvala rudarski sektor, sačuvala veliki broj radnih mjesta u rudarstvu, energetici i pratećim industrijama i da bi zadovoljila ekološke standarde (uvažavajući prezentirane rezerve uglja) mora svoje stare blokove zamijeniti novim najsavremenijim koji će biti kogenerativni, visokoefikasni i koji će ispunjavati najstrožije standarde Bat-a.

# 5. LISTA AUTORA / LIST OF AUTHORS


Miloš Banjac
Ministry of Mining and Energy, Serbia/
University of Belgrade,
Faculty of Mechanical Engineering,
Department for Thermomechanics,
Belgrade, Serbia

Zoran Božović,
VPC-East/Senior Advisors
Kralja Milana 3, 11000 Beograd, Srbija

Dejan Cvetinović
Univerzitet u Beogradu,
Institut za nuklearne nauke "Vinča"
Laboratorija za termotehniku i energetiku
P.p 522, 11001 Beograd, Srbija

Nijaz Delalić
Univerzitet u Sarajevu,
Mašinski fakultet Sarajevo,
Katedra za energetiku,
Vilsonovo šetalište 9, 71000 Sarajevo
Bosna i Hercegovina

Milić Erić
Univerzitet u Beogradu,
Institut za nuklearne nauke "Vinča"
Laboratorija za termotehniku i energetiku
P.p 522, 11001 Beograd, Srbija

Dionysios Giannakopoulos
Centre for Research and Technology Hellas
Chemical Process and Energy Resources
Institute
Egialias 52, 15125 Marousi, Athens, Greece

Dušan Golubović
Univerzitet u Istočnom Sarajevu,
Mašinski Fakultet Istočno Sarajevo,
Katedra za termoenergetiku i procesno
mašinstvo, Vuka Karadžića 30,
71123 Istočno Novo Sarajevo, Bosna i
Hercegovina

Anes Kazagić
JP EP BiH d.d. Sarajevo,
Vilsonovo šetalište 15,
71000 Sarajevo, Bosna i Hercegovina

Aleksandar Knežević
IMPULSIO, Pokret za vladavinu znanja,
Sarajevo, Bosna i Hercegovina

Grzegorz Kotte
Kozienice Power Plant,
Enea Wytwarzanie Sp. z o.o., Świerże Górne,
Aleja Józefa Zielińskiego 1, 26-900 Kozienice,
Poland

Edin Lapandić
JP EP BiH d.d. Sarajevo,
Vilsonovo šetalište 15,
71000 Sarajevo, Bosna i Hercegovina

Dragomir Marković
VPC-East/Senior Advisors,
Kralja Milana 3, 11000 Beograd, Srbija

Zoran Marković
Univerzitet u Beogradu,
Institut za nuklearne nauke "Vinča"
Laboratorija za termotehniku i energetiku,
P.p 522, 11001 Beograd, Srbija

Ajla Merzić
JP EP BiH d.d. Sarajevo,
Vilsonovo šetalište 15,
71000 Sarajevo, Bosna i Hercegovina

Miodrag Mesarović
Serbian WEC Member Committ,
Energoprojekt Entel, Belgrade, Serbia

Dimšo Milošević
MH „Elektroprivreda RS"- MP A. D. Trebinje
ZP „R i TE Ugljevik" A. D. Ugljevik,
Bosna i Hercegovina

Petar Gvero
Univerzitet u Banjoj Luci,
Mašinski fakultet Banja Luka,
Bulevar vojvode Stepe Stepanovića 71,
78000 Banja Luka, Bosna i Hercegovina

Michał Jabłoński,
Polish Power Plants Association (TGPE),
Chalubinskiego 8, Warsaw, Poland

Omer Jukić
ANUBiH/ OTN,
Odbor za energiju, energetiku i okoliš,
Bistrik 7, 71000 Sarajevo, Bosna i Hercegovina

Emmanuel Kakaras
Centre for Research and Technology Hellas,
Chemical Process and Energy Resources
Institute, Egialias 52, 15125 Marousi, Athens/
National Technical University of Athens,
Laboratory of Steam Boilers and Thermal
Plants, 9 Heroon Polytechniou, 15780 Zografou,
Athens, Greece

Gligor Kanevče
Academy of Science of North Macedonia,
Research Center for Energy and Sustainable
Development,
Bul. Krste Misirkov 2, Skopje, North Macedonia

Emmanouil Karampinis
Centre for Research and Technology Hellas,
Chemical Process and Energy Resources
Institute, Egialias 52, 15125 Marousi, Athens/
National Technical University of Athens,
Laboratory of Steam Boilers and Thermal
Plants, 9 Heroon Polytechniou, 15780 Zografou,
Athens, Greece

Zdravko Milovanović
Univerzitet u Banjoj Luci,
Mašinski fakultet Banja Luka,
Katedra za hidro i termoenergetiku,
Bulevar vojvode Stepe Stepanovića 71,
78000 Banja Luka, Bosna i Hercegovina,

Mustafa Musić
JP EP BiH d.d. Sarajevo,
Vilsonovo šetalište 15,
71000 Sarajevo, Bosna i Hercegovina

Miroslav Nikolić
JP EP HZHB d.d. Mostar,
Dr. Mile Budaka, 88000 Mostar,
Bosna i Hercegovina

Ronald Rost
VPC GmbH/ Sales Department,
Charlotten Strasse 18, 10117 Berlin, Germany

Izet Smajević
Akademija nauka i umjetnosti Bosne i
Hercegovine, Odjeljenje tehničkih nauka,
Odbor za energiju, energetiku i okoliš,
Bistrik 7, 71000 Sarajevo, Bosna i Hercegovina

Predrag Stefanović
Univerzitet u Beogradu,
Institut za nuklearne nauke “Vinča”
Laboratorija za termotehniku i energetiku,
P.p 522, 11001 Beograd, Srbija

Miladin Trbić
EFT Group, TE Stanari,
74208 Stanari, Bosna i Hercegovina

Boško Vuković
MH „Elektroprivreda RS“- MP A. D. Trebinje,
ZP „R i TE Gacko“ A. D. Gacko,
Bosna i Hercegovina



Javno preduzeće

**ELEKTROPRIVREDA BOSNE I HERCEGOVINE**

d.d. - Sarajevo