European Policy On Air Pollutants And Basic Thermal Power Plants In Bulgaria

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***Abstract* — The aim of the paper is to discuss the basic Bulgarian Thermal Power Plants (TPPs) operating opportunities in conditions of the EU present and future air pollution restrictions, not taking into account the long-term "Green deal" implementation. These TPPs are determining in Bulgarian energy production sector, using the only local available energy source – low calorific lignite with high sulfur and ash content, producing great quantity greenhouse and acidic gases, ash and dust, containing heavy metals, poisonous nonmetals etc. The TPPs are quite different in age – the energy blocks of public, TPP (Maritsa East -2) was put into operation in period from 1966 to 1995, in very different ecology requirements. The other two, private (American owned) TPPs are much younger, entered into operation in 2009 and 2011 for "Contour Global Maritsa East 3 TPP" and "AES Galabovo TPP" respectively. From ecological point of view, these TPPs are similar, using same fuel, combustion technology and cleaning equipment – ESP and wet flue-gas desulfurization. The three TPPs are the keystones of electrical energy production, but the public one plays significant social role, keeping the low energy price and giving well-paid job for lot of people in the region. Could they survive ecologically and financially? The future and the geo-political moods will show. Taking into account, that the operating of the only Bulgarian NPP and natural gas supply are closely depended on Russia policy, the Bulgarian energy sector could not expect the best future.**

Keywords—lignite TPP, ecology, air pollution restrictions, energy sector survival, geo-policy and energy dependence.

I. INTRODUCTION

Bulgarian energy sector is highly developed, but the significant part of energy capacities are built in years of socialism in quite different ecology regulations and depended both on imported energy sources (anthracite coal and nuclear fuel from Russia and Ukraine) and only local (low quality lignite). Energy independence could be achieved using local resource, but it is very dirty fuel, coursing environmental pollution and large quantities of greenhouse gas (GHG) emissions that are unacceptable in mood of green deal and air quality preservation current and future regulations in EU. The discussion is focused on basic lignite TPPs and their ability to cover present and future environmental EU requirements.

This paper discusses the viability of the basic Bulgarian fossil TPPs in short and mean future, depending on the harmful emissions into the atmosphere without discussing GHG emissions influence up to 2030.

II. BASIC TPPS IN EAST MARITSA REGION

A. TPPs Location and Installed Capacity

There are three TPPs in East Maritsa region which could be considered a basic, fig.1, table 1.

Figure 1

TABLE I. BASIC TPPS IN EAST MARITSA REGION

TPP	$P_{inst.}$, MW	In operation	property
Maritsa East 2	1620	1966 ÷ 1995	public
AES Galabovo	670	2011	private
Contour Global ME-3	910	2009	private

As it seen from table 1, total installed capacity of the basic TTPs is about 3200 MW and together with NPP's 2000 MW are able to cover the base energy consumption over 5000 MW in winter months when the load is biggest. Except these basic TPPs, there are about 10 smaller TPPs in partial operation in Bulgaria and one large in cool reserve with total installed capacity approximately 3000 MW. Total power capacity of HPPs and Pumped Storage HPPs is about 2800 MW [3], Wind PPs – 700 MW [4], PV – 1000 MW [4], and biomass – 30 MW [4].

It seems that compared to the total installed capacity of approximately 12 700 MW, the basic TPPs in East Maritsa Region are not so significant for energy system, but is it like this?

B. Why East Marica TPPs are Important for Bulgarian Energy Sector?

At first, for the local fuel and the technical infrastructure availability, and at second for the energy independence of the country, provided by the most modern TPPs – the basic. The publish Maritsa East -2 TPP is due for keeping the electrical net frequency and restarting the net operation after potential crush. There is a social and respectively political aspect as well. The companies in mine-energy complex Maritsa East

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are one of the largest employers in Bulgaria and feed the large potential electorate. The direct jobs of the mine-energy complex, which are count at 12 700 [12] used to have a relatively high salary for the local standards and could be expected to fight for keeping this in the future. The indirect jobs related to Bulgarian coal sector are calculated at 46 850 [12]. Therefore, closing the mine-energy complex Maritsa East is very difficult from social and political point of view.

If we look at the structure of the electrical generation in the 2020's summer days fig.2 [1], when the generation is lowest for the lowest consumption and the PV renewables are working at their maximum with priority in dispatching, the TPPs keep significant deal of the generation even if the two blocks of NPP are in operation.

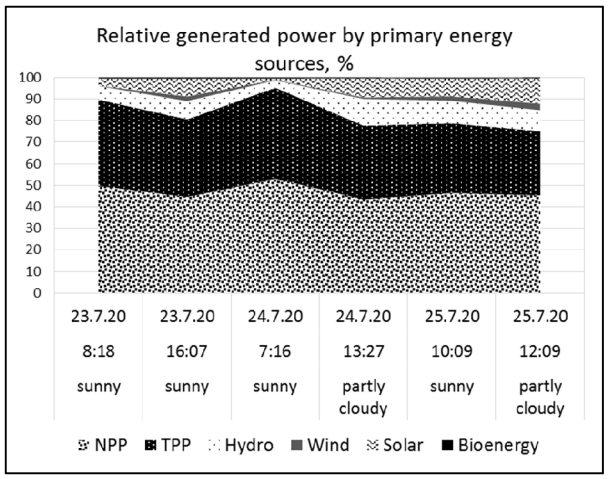


Figure 2

The lines of generated power by primary source for period of last two years fig. 3 [8] clearly represents the dependence of TPP's generation from renewables – the line of TPPs+NPP is a mirror reflection of the renewables line. Nevertheless, the share and the importance of two types generating capacities for the energy system are quite different, fig. 4 [8].

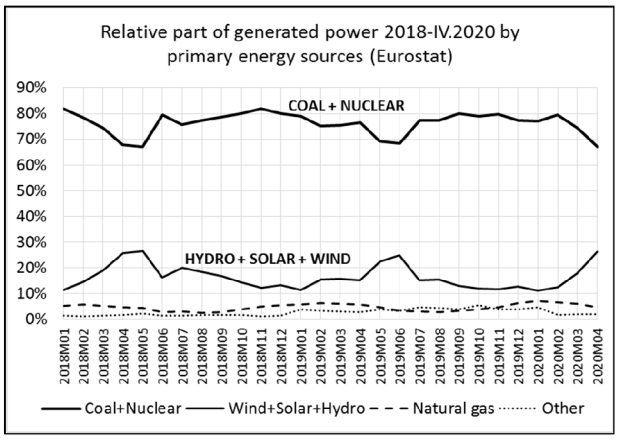


Figure 3

What does it mean?

Bulgarian energy system could not operate reliably without Maritsa East TPPs in the present, but they operate at a partial load. We cannot close, but suppress TPPs to keep working the renewables at their maximum.

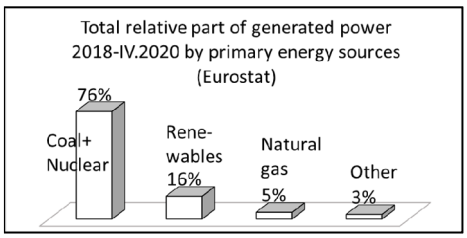


Figure 4

The moment generation of the system [1] and of the Maritsa East 2 TPP [5] could be seen online in real time and for instance on 19.08.2020 at 8:50 the Maritsa East 2 TPP generates 368MW, which means 23% of nominal capacity, and the structure of electrical generation at the same time is seen on fig. 5.

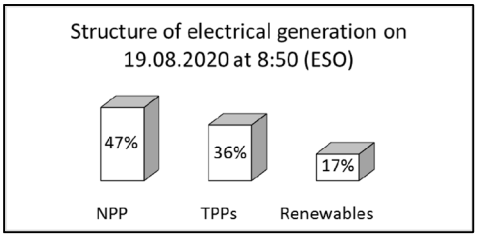


Figure 5

The PVs and WPPs cannot cover even a part of the load constantly, they are unreliable, cannot keep the frequency of the net, their energy is expansive and their operation is unpredictable, but it is claimed that they are the future.

However, there is another point of view – ecological and geopolitical in mood of EU environment conservation policy. Bulgaria is an EU member and have to respect EU regulations.

The question is how to keep the goat alive and the wolf to be well fed. There is no answer at the time.

C. Fuel Content and technology of energy production

Lignite in the East Maritsa coal deposit is low in calories, high in ash, sulfur and moisture, table 2 [5].

TABLE II. EAST MARITSA'S LIGNITES CONTENT

Caloric content	Ashes	Moisture	Sulfur	Carbon
1430 ÷ 1600 kcal/kg	30÷47%	47÷54%	2,1÷3,6%	18 ÷ 22

Nitrogen content in the fuel is 0,2÷0,4% [5], and almost all elements in Mendeleev table could be found.

The fuel is processing by pulverized coal combustion technology and dry slagging at 1000÷1200°C in combustion chamber.

III. EVOLUTION OF EU AIR POLLUTION RESTRICTIONS POLICY

With a view to protecting the environment and human health, restrictions on the release of harmful emissions into the atmosphere are becoming and will become increasingly stringent in the EU.

Here are considered the EU restrictions for lignite boilers with thermal input over 300 MWth, such as those installed in the base TPPs in the East Maritsa region of Bulgaria. Since

the values of some of the constraints are formulated in intervals, the most liberal is considered admissible.

The development of the policy for limiting traditionally controlled emissions of dust, sulfur and nitrogen oxides is shown below. For sulfur oxides fig.6, the levels drops significantly from 400 in 2001 to 130 after 2020 [9], [10], [11].

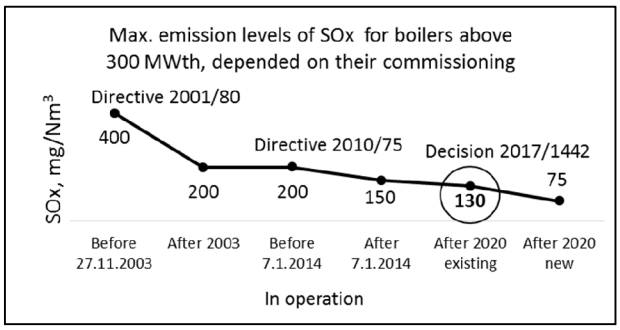


Figure 6

The legislator allows operation with higher emissions of sulfur oxides for local lignite boilers with available wet flue gas desulfurization (WFGD) up to 320 mg/Nm^3. Instead of a maximum permissible concentration in the flue gases, it regulates a minimum degree of desulfurization alternatively – at least 97%, fig 7 [9], [10], [11].

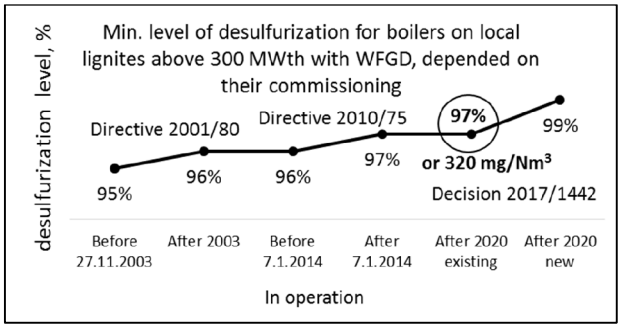


Figure 7

The limits for nitrogen oxides of local lignite boilers are slightly dropped - from 200 to 175 mg/Nm^3, fig. 8 [9], [10], [11]. This high level is only valid for fluidized bed combustion (FBC) boilers put into operation no later than 7 January 2014 and for lignite-fired pulverized combustion (PC) boilers like operating in Maritsa East region basic TPPs.

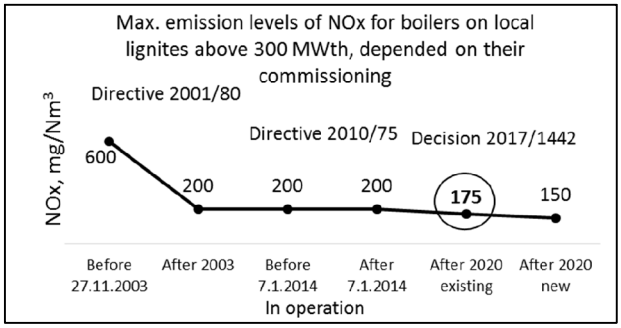


Figure 8

The limit for fine particulate matters (PM) has been reduced from 20 to 12 mg/Nm^3, i.e. by only 60%, fig.9 [9], [10], [11], but this value may be unattainable for older filter designs.

The special thing in Decision 2017/1442 is that for new boilers put into operation after 2020, the level of dust emissions is 5 mg/Nm^3 regardless of their capacity.

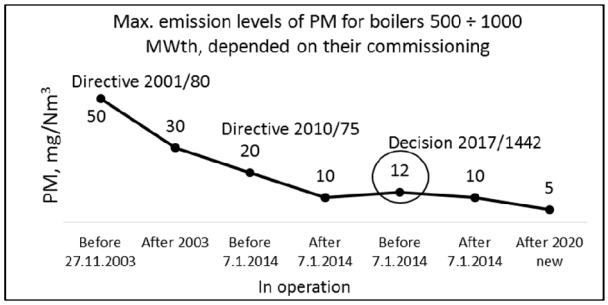


Figure 9

The next important point in Decision 2017/1442 is the introduction of restrictions on pollutants, which so far have not been limited by values of maximum allowable emissions, Table. 3. The limits are for installed capacity above 300MWth.

TABLE III. ADDITIONAL POLLUTANTS RESTRICTIONS

Pollutant	Max. value	Comment
CO	140 mg/Nm^3	limitations due to existing boiler design (lignite) in operation before 2014
HCl	7 mg/Nm^3	existing boiler with WFGD (lignite)
HF	7 mg/Nm^3	existing boiler with WFGD (lignite)
Hg	10 μg/Nm^3	existing boiler (lignite)
NH_3	15 mg/Nm^3	existing boiler at variable load (lignite) if SCR/NSCR installed

In order to reduce greenhouse gas emissions, Decision 2017/1442 imposes requirements for minimum efficiency of boilers and minimization of electrical consumption for facility operation – i.e. energy efficiency. For existing lignite-fired units with a net heat output below 1000 MWth, an electrical efficiency of at least 31,5% or an increase of at least 3% compared to the original is required.

Electricity consumption for production needs must be reduced by replacing equipment, electric motors, frequency control, optimization of modes through automatic controls, replacement of production and outside lighting, etc. [13], [14], [15].

IV. AIR POLLUTIONS FROM TPPS IN EAST MARITSA REGION

The basic thermal power plants in the Maritsa basin are equipped with systems for continuous monitoring of harmful emissions into the atmosphere and immissions in the most endangered settlements. The results of the measurements are summarized and presented to the "Ministry of Environment and Water" in the form of an "Annual report on the implementation of the activities regulated in the Complex Permit". The Ministry uploads them on its website, making them freely available to every citizen.

Any excess of pollutants is also reported immediately, as well as the reasons and corrective action taken. The results of the reports for 2019 are summarized in table IV, [2]. Detailed

data on mercury and halogen gas emissions are not available and there are no ammonia emissions, as secondary nitrogen oxide, reduction facilities are not installed.

TABLE IV. BASIC CONTROLLED ATMOSPHERIC POLLUTANTS

TPP	WFGD %	NOx	PM	CO
	%	mg/Nm^3	mg/Nm^3	mg/Nm^3
M. East-2	av.97%	av.137	< 8	< 25
C. Global	av.96,3%	av.146	< 1	av. 0,7
AES	> 97,5%	< 190	< 3	NA

V. DISCUSSION ABOUT AIR QUALITY POLICY OF EAST MARITSA REGION TPPS

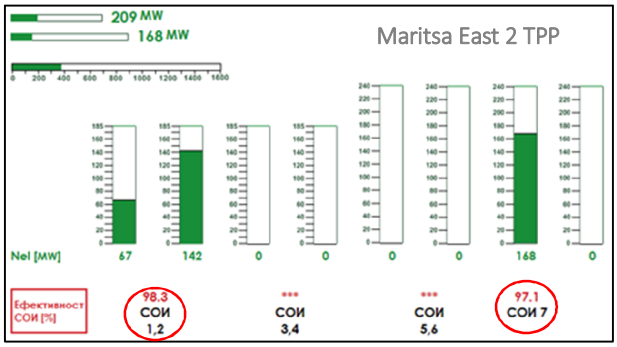
In 2021, the EU is expected to impose the recommended restrictions in Decision 2017/1442 through a new Directive. The question arises whether the basic thermal power plants in the Maritsa region are implementing them. The answer is shown in table V.

TABLE V. BASIC CONTROLLED ATMOSPHERIC POLLUTANTS

TPP	SO_2 mg/Nm^3 WFGD %	NOx	PM	CO
		mg/Nm^3	mg/Nm^3	mg/Nm^3
M. East-2	?/YES	?/YES	YES	YES
C. Global	NO	?/YES	YES	YES
AES	YES	NO	YES	NA

A. Sulfur oxides reduction

The freely available information in real time (21.08.2020) shows that the degree of desulfurization of the currently operating boilers of TPP Maritza East 2 is between 97.1 and 98.3 fig. 10, and average for 2019 is 97% [5], which suggests that the plant probably will meet the requirements for desulfurization of the new Directive. The plant's investment policy also confirms this assumption. The AES TPP meets the requirements for SOx reduction with more than 97,5% efficiency [6]. Contour Global does not meet the requirements with 96% efficiency [7].



Real time data: https://www.tpp2.com/site/realTimeData.html

Figure 10

B. Nitrogen oxides reduction

All three plants are not equipped with systems for secondary cleaning of flue gases from nitrogen oxides, relying on low-emission burners and relatively low temperatures in the combustion chamber due to the low calorific value of the fuel.

From the data in table IV it can be assumed that TPPs Maritsa East-2 and Contour Global will meet the requirement for maximum permissible concentration (MPC) of 175mg/Nm^3, while AES will not meet them.

C. PM reduction

All three TPPs meet the PM requirements.

D. Additional controlled pollutants

- All three TPPs meet the CO requirements.
- Mercury emission data are based on once-a-year measurements, which cannot be considered representative. The results of the measurements for 2019 are shown in table VI.

TABLE VI. MERCURY CONTENT IN FLUE GASES

Mercury content, µg/Nm^3		
Maritsa East 2	*Contour Global*	*AES Galabovo*
Av. 27,65	5,2	6,5
	1,2	10,9

It can be concluded that TPP Maritsa East 2 exceeds the permissible emissions for mercury by more than 2,5 times. One of the AES boilers slightly exceeds the norm.

- As there are no published data from measurements for the content of HCl and HF in the flue gases, no predictions can be made.
- No ammonia emissions are expected, as there are no published investment intentions for the construction of secondary nitrogen oxide reduction plants.

VI. CONCLUSIONS

None of the basic TPPs in the East Maritsa Basin meets all the minimum requirements for harmful emissions into the atmosphere regulated in Decision 2017/1442. There are no published investment intentions for the construction of installations for secondary purification of flue gases from nitrogen oxides, mercury and hydrogen halides, which suggests that the three TPPs intend to operate in a derogation mode until 2030. TPP Contour Global does not intend to increase the efficiency of desulphurization installation to the minimum 97% regulated in the EU Decision.

According to [11], fossil TPPs capacity in Bulgaria have to be reduced with 86% after 2030, i.e. only one of the three TPPs will remain in operation, and in view of the strategic importance of TPP Maritsa East 2, probably it will remain in operation after the necessary reconstructions. Another reason for such an assumption is the possibility to invest public funds in reconstructions of public TPP unlike private. Social and political reasons are another argument to confirm this assumption.

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REFERENCES

[1] Energy System Operator (ESO), http://www.eso.bg/?did=124.

[2] Executive Environmen Agency (EEA), http://eea.government.bg/bg/r-r/r-kpkz/godishni-dokladi-14/index.

[3] National Electric Company, https://vec.nek.bg/stations.

[4] Register of renewable sources, https://www.veiregistar.bg/objects.

[5] TPP Maritza East 2, https://www.tpp2.com/.

[6] TPP AES http://aes.bg/?gclid=EAIaIQobChMI99Pppqy46wIV-34BQBh2FHAuMEAAYASAAEgLFQ_D_BwE.

[7] TPP ConturGlobal, https://www.contourglobal.com/asset/maritsa-east-3.

[8] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do.

[9] EU Directive 2001/80.

[10] EU Directive 2010/75.

[11] EU Dicision 2019/1442.

[12] Alves Dias, P. et al., EU coal regions: opportunities and challenges ahead, EUR 29292 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-89884-6, doi:10.2760/064809, JRC112593.

[13] Valentin Kolev, Dilyana Gospodinova, Iva Draganova, Policy and Energy Efficiency in the Context of the National Zero Emmision Building plan in Bulgaria, 2019 11th Electrical Engineering Faculty Conference (BulEF), 978-1-7281-2697-5/19/$31.00 ©2019 IEEE.

[14] Valentin Kolev, Dilyana Gospodinova, Iva Draganova, Trends in Energy efficiency and CO2 emissions according to Bulgarian National Energy Efficiency plan, 2019 11th Electrical Engineering Faculty Conference (BulEF), 978-1-7281-2697-5/19/$31.00 ©2019 IEEE.

[15] Valentin Kolev, Iva Draganova, Application of variabe frequency drives (VFD) with large 6 kV asynchronous motors, 2019 11th Electrical Engineering Faculty Conference (BulEF), 978-1-7281-2697-5/19/$31.00 ©2019 IEEE.