Greenhouse Emissions And Prospects For Local Fuel TPPs In Bulgaria

Nikolai Vitkov
Faculty of Electrical Engineering,
Technical University of Sofia
Sofia, Bulgaria
nvitkov@tu-sofia.bg

***Abstract* — The basic energy TPPs in Bulgaria operate with the only local energy resource of low-caloric lignite. Regulation 2018/842 of EU does not set high restrictions on greenhouse gas emissions from Bulgarian TPPs until 2030, which would allow operation of lignite-fired power plants, but after that the prospects for the fate of fossil energy are not promising. The operation of the only Bulgarian NPP (Kozloduy) depends on external geopolitical factors and its future is uncertain. The basic TPPs and NPP produce about 75% of the electricity in Bulgaria. The question is whether the Bulgarian energy sector will be able to adapt to the new requirements - minimum carbon emissions and pollutants emitted into the atmosphere. Technical possibilities exist and can be particularly financed by the EU, but up to 2020 there are no energy projects in Bulgaria with the potential to replace the basic fossil thermal power plants, and the construction of large energy facilities requires, among other things, significant time.**

The paper attempts to assess the energy policy regarding the Bulgarian TPPs in the spirit of Regulation 2018/1999 and the prepared "Integrated Plan in the field of energy and climate of the Republic of Bulgaria 2021 - 2030". The alternative of adaptation of Bulgarian energy sector to EU ecology requirements means complete energy dependence on imported electricity after 2030.

Keywords—local energy resource, basic TPP, energy sector adaptation, ecology, EU regulations, energy dependence.

I. INTRODUCTION

The paper attempts to assess the energy policy regarding the Bulgarian TPPs in the spirit of Regulation 2018/1999 and the prepared "Integrated Plan in the field of energy and climate of the Republic of Bulgaria 2021 - 2030".

II. REGULATORY FRAMEWORK AND GREENHOUSE GAS EMISSIONS FROM THE REPUBLIC OF BULGARIA

The European Union has set itself the goal of sharply reducing carbon emissions to levels that will ensure a slowdown in global warming in the coming decades, and with Regulation 2018/1999 [1] formulates 5 interrelated dimensions (policies) for achieving it:

- ensuring energy security;
- development of a competitive internal energy market;
- increasing the energy efficiency of industry and the household sector;
- decarbonisation of energy;
- development and application of research and innovation to achieve high competitiveness.

The direct greenhouse gas emissions generated by the Republic of Bulgaria in the last 10 years maintain a trend of slight decline fig. 1 [2], which is primarily due to the commissioning of significant renewable capacities and limitation of the working hours of the lignite power plants at the expense of the renewables and NPP.

The largest share of the generated carbon emissions from the Bulgarian economy falls on the energy sector fig. 2 [2] and logically the potential for their reduction can be sought in the limitation of the installed capacities and working hours of the fossil energy - TPPs of lignite and coal. The drops in the oscillations coincide with the economic recessions of 2009 and 2013.

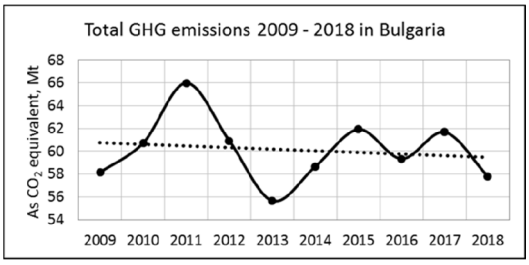

Figure 1

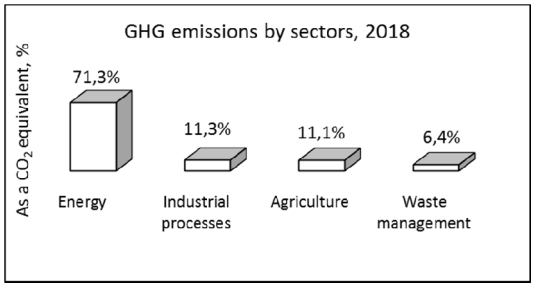

Figure 2

The structure of greenhouse emissions fig. 3, [2] also shows the leading position of energy - emissions of carbon dioxide and nitrogen oxides predominate.

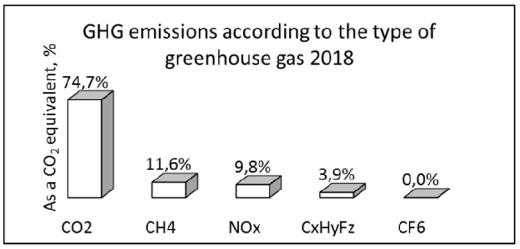

Figure 3

978-1-7281-9439-4/20/$31.00 ©2020 IEEE

Greenhouse gas emissions per capita are slightly lower compared to the average for the EU, fig. 4 [3].

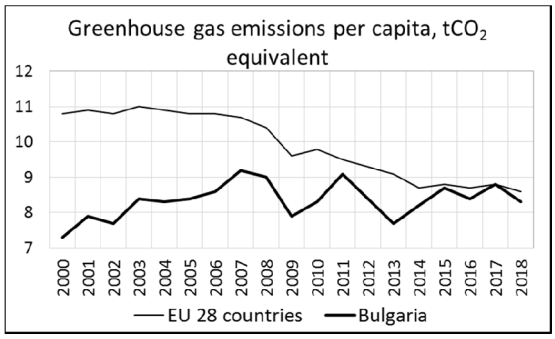

Figure 4

The main reasons for generating greenhouse emissions are:

- significant share of fossil energy in the energy mix;
- low energy efficiency of industry and buildings;
- obsolete car fleet;
- primitive combustion installations for heating in small settlements;
- deforestation, etc.

In order to meet the requirements of EU Regulation 2018/1999, Bulgaria has developed an "Integrated National Plan in the Field of Energy and Climate 2021-2030" [4], which mostly concerns the operation of coal and lignite TPPs.

III. Integrated National Plan in the Field of Energy and Climate 2021-2030

The main policies set in the national plan are summarized in table I.

TABLE I. National Plan Main Policies

Priorities of the policies in the energy sector of the Republic of Bulgaria					
1	2	3	4	5	**6**
Energy security	***Reducing GHG emissions***	*Increasing the share of renewables*	*Improving energy efficiency*	*Building a competitive energy market*	***Improving the use of local fuels***

The most significant influence on the fate of fossil energy in the future have the policies in columns 2 and 6. The reduction of greenhouse gas emissions is expected to occur according to fig. 5 [4].

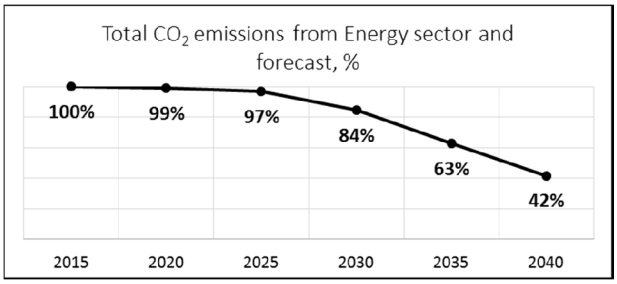

Figure 5

It is noteworthy that for the period 2015 – 2025 no reduction of emissions is planned and in the period 2025-2030 it is only 16% compared to the base 2015. This means that decommissioning of base TPPs is not expected until 2030. After 2030 to 2040, emissions should be sharply reduced to 42% from the base year. It can be assumed that by 2040 one or two base TPPs should remain operational. In [4] it is envisaged to change the structure of the generating capacities according to fig. 6.

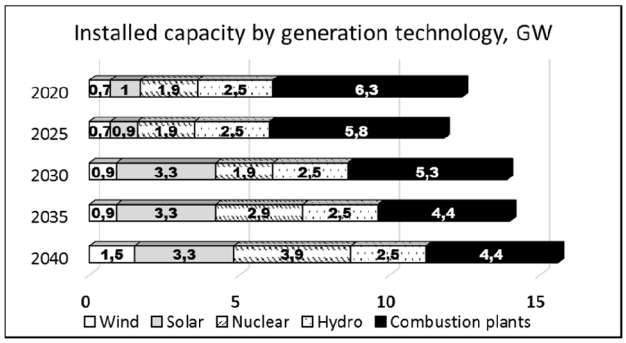

Figure 6

By 2040, the total generating capacity of combustion plants (TPPs) is projected to amount to 4.4 GW. Simple calculations show that then most likely the basic TPPs in the Mari basin and TPP Varna remain in operation, Table 2. There is a second unlikely option - decommissioning of the two US plants AES Galabovo and Contour Global ME-3, and remain in operation of TPP Brikel and TPP Bobovdol, Table 3.

TABLE II. Most Likely TPPs In Operation By 2040

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
TPP Varna	1260	1968 ÷ 1979	private
Total	**4460**		

TABLE III. Unlikely TPPs In Operation By 2040

TPP	**$P_{inst.}$, MW**	**In operation**	**property**
Maritsa East 2	1620	1966 ÷ 1995	public
TPP Varna	1260	1968 ÷ 1979	private
TPP Brikel	850	1960 ÷ 1964	private
TPP Bobovdol	630	1973 ÷ 1975	private
Total	**4360**		

Other options are possible, incl. the last two TPPs to run on waste fuel (i.e. to burn Europe's waste, as recently attempted illegally). The specific configuration of the facilities that will not be permanently decommissioned will depend on the strength of geopolitical and oligarchic interests.

On the other hand, the integrated plan envisages the net production of electricity from combustion plants by 2040 to be about 3 times lower compared to the base 2015, fig. 7 [4].

This leads to the conclusion that by 2040 only one TPP will be operating of natural gas, and three or four large TPPs will be in cold reserve. There is hardly a rich enough side of the world that would afford such extravagance. Obviously, this is not a rational and feasible plan.

Against the background of the huge combustion installed capacities by 2040, the structure of electricity production

according to the primary fuel is seen on fig. 8 [4] (p. 229, fig. 59).

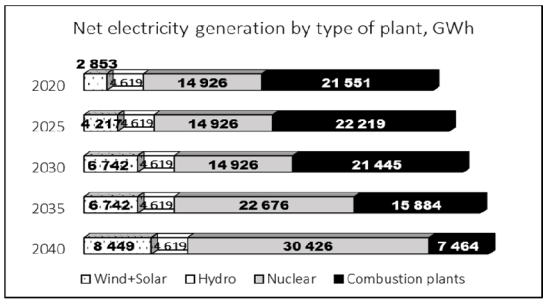

Figure 7

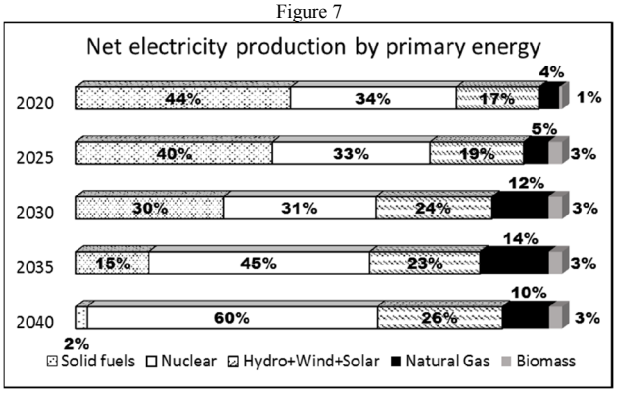

Figure 8

From Fig. 8 it can be concluded that the electricity produced from solid fuels by 2040 is projected to be 2% (probably waste fuel) and biomass 3%. The share of natural gas is only 10%, i.e. by 2040, one natural gas-fired power plant with an installed capacity of less than 500 MW can operate at 8 000 operating hours per year, and 3.9 GW remain in cold reserve capacity.

Why does the integrated plan set such an illogical forecast, which keeps in cold reserve capacities approximately equal to 4 nuclear units of 1 GW?

The answer is: because the construction of a new nuclear power plant of 1GW by 2035 and another 1GW by 2040 is not realistic at all, given that by mid-2020 there are no indications of a political decision and preparation of a serious investment proposal and clear geopolitical approval.

The future of the two operating nuclear units is clear until 2028-29, when the current extension of their operation expires, and a new extension depends on Russia and is not certain.

If the worst case scenarios are considered:

a) decommissioning of Kozloduy NPP by 2028 and commissioning of a new NPP by 2035;

b) decommissioning of Kozloduy NPP by 2028 without construction of a new nuclear power plant,

the structure of the generated electricity would take the form of fig. 9 and 10.

In this case, keeping combustion generating capacity of 3.9 GW in cold reserve capacity makes real sense.

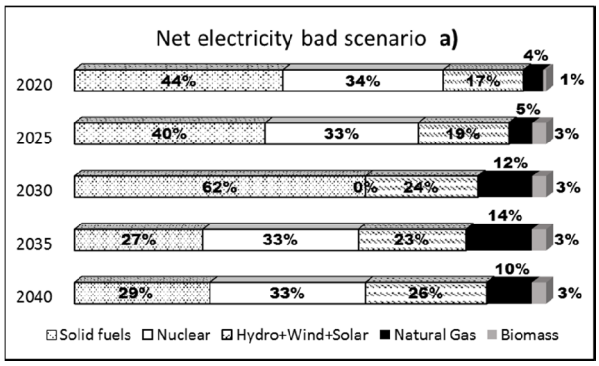

Figure 9

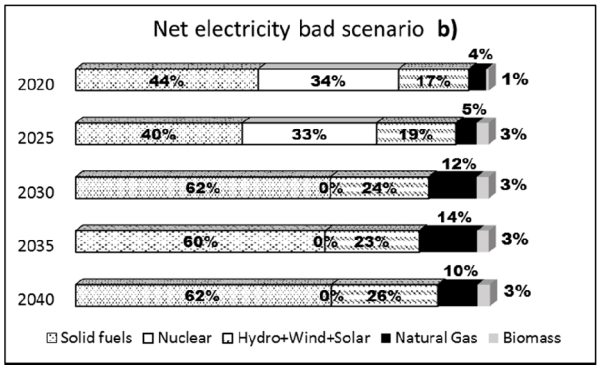

Figure 10

IV. Discussion Of Whether The Integrated Plan [4] Achieves The Declared Objectives (Policies)

A. Energy security

It is clear that in the spirit of decarbonization, a generation structure similar to the hypotheses of Fig. 9 and 10 is inadmissible. The only possibility after 2030 is the closure of all fossil thermal power plants and import of 30-60% of the country's required electricity. Investment intentions to build new main power lines to neighboring countries support such a scenario.

Diversification of primary energy sources is not envisaged, despite the construction of the Balkan Stream gas pipeline, interconnections to neighboring countries, the purchase of 20% of the liquefied gas terminal near Alexandroupolis and an increase in the capacity of the Chiren gas storage facility. What is the meaning of these investments, since the strategy envisages an increase in electricity from natural gas by 5-6% is not clear.

Bulgaria's energy security will obviously depend on electricity imports from neighboring countries, which means full energy dependence.

B. Reducing GHG emissions

The goal will be achieved by importing a large part of the required electricity 40 - 60%.

C. Increasing the share of renewable energy

The goal has been achieved by half and there is no doubt that it will go on schedule, along with raising the price of electricity.

D. *Increasing energy efficiency*

The goal will be achieved at the initiative and at the expense of consumers by raising the price of electricity.

E. *Building a competitive electricity market*

The goal will be met in order to be profitable large-scale electricity imports for all in the chain - generation, transmission distribution.

F. *Increasing the use of local fuels*

Apparently, this goal (policy) is written to deceive those working in the mining and energy sector in order to postpone protests and domestic political turmoil in the near future. From
Fig. 8 it is clear that the mining and energy sector will be closed gradually and completely in the period 2030 - 2040. After 2040, the use of local fossil fuel is not planned at all.

V. Possible Technical Solutions For The Use Of Cobustion Generating Capacities With Low Emission Factor In Bulgaria

In Europe, unlike in Bulgaria, natural gas is considered as a transitional fuel until full decarbonization is achieved, probably on the basis of advanced nuclear technologies, incl. thermonuclear fusion, because it is clear to everyone that photovoltaics and wind farms cannot replace fossil energy. There are several opportunities for Bulgaria.

A. *Replacement of fuel base by gasification of lignite-fired power plants*

Technically feasible measure with small investments (gasification and replacement of burners). The effect would be unsatisfactory, both from an environmental and an economic point of view [5] - leading to relatively high carbon emissions and high electricity prices. It can only be considered as a transitional technology. It does not use local fuels.

B. *Construction of new natural gas thermal power plants with gas turbines operating on integrated combined cycle technology (ICCGT)*

In the integrated combined cycle (gas turbine with utilization of heat from the flue gas in the steam cycle - secondary generation) an electrical efficiency of up to 57-60% is achieved and the carbon footprint is the lowest - about 350 tCO_2e / GWh [5]. The technology is considered promising and is being developed by the largest energy corporations - General Electric, Westinghouse, Siemens, Alstom, Mitsubishi and others. The individual power units are modular and are installed in a relatively short time. The cost of the investment is high, but in the spirit of the green deal, much can be shared by the EU, especially if a European equipment supplier is chosen.

Despite the new gas pipeline and interconnections, i.e. provided fuel base, for such technology in the integrated plan [4] is not told a word. Instead, a potential possibility is being considered for the installation of gas turbines for cogeneration for district heating.

C. *Construction of new TPPs on synthetic gas (syngas) with gasification of solid fuels and gas turbines operating on integrated combined cycle technology (IGCCGT)*

The technology is considered to be particularly promising as it achieves an acceptably low carbon footprint, especially in the co-gasification of coal / lignite with biomass / waste fuels with the installation of state-of-the-art syngas purification systems before the gas turbine. The electrical efficiency is lower than with natural gas fuel due to the cryogenic technology for the production of pure oxygen needed for the gasification process. A breakthrough in the technology and mass application of nano-membranes is expected to provide pure oxygen for gasification, which makes the efficiency of the installation comparable to that of natural gas. Gas turbines operating with low calorific syngas, obtained by gasification with atmospheric air and / or water vapor, have also been developed. This technology could cover a significant part of the country's energy needs in the transition period based on local fuel with relatively low GHG emissions, partial preservation of jobs in the mining and energy sector and would solve the problem of landfilling biomass and municipal waste through thermal recycling for energy production. Nothing like this is foreseen in the integrated plan [4].

VI. Conclusions

"Integrated plan in the field of energy and climate of the Republic of Bulgaria 2021 - 2030" was prepared as a formal implementation of Regulation 2018/1999 of the EU without a vision for energy sector development after 2030.

Everything possible has been done to preserve the structure of the energy mix until 2030 and to preserve the basic combustion capacities until 2040, although only as a cold reserve capacity.

No significant diversification of the primary fuel of TPPs is envisaged in the transition period 2020 - 2040.

The application of innovative technologies for electricity generation is not envisaged which is contrary to EU policy for development and application of research and innovations to achieve high competitiveness.

After 2030, significant dependence on imported electricity can be expected. Investing in modern technologies for gasification of solid fuels achieving a sufficiently low carbon footprint could provide the necessary electricity in the transition period to full decarbonisation of energy production sector. Advanced nuclear technologies probably are the future.

Acknowledgment

The author/s would like to thank the Research and Development Sector at the Technical University of Sofia for the financial support.

References

[1] Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the governance of the Energy Union and climate action.

[2] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en.

[3] Eurostat, https://ec.europa.eu/eurostat/tgm/download.do?tab=table&plugin=1&language=en&pcode=t2020_rd300.

[4] Integrated plan in the field of energy and climate of the Republic of Bulgaria 2021 - 2030, https://www.moew.government.bg/bg/klimat/strategicheski-dokumenti/strategicheski-dokumenti/.

[5] EIB Project Carbon Footprint Methodologies, European Investment Bank, Methodologies for the Assessment of Project GHG Emissions and Emission Variations, 2020, ISBN 978-92-861-4715-9 DOI 10.2867 / 401801.