Energy Policy Studies

IGNACY LUKASIEWICZ
ENERGY
POLICY
INSTITUTE

1(5) / 2020

Cover design: Aku Studio

Typesetting: Lidia Mazurkiewicz, MSc, Eng.

Publisher: Ignacy Lukasiewicz Energy Policy Institute
eps@instytutpe.pl
http://www.instytutpe.pl/eps/
http://www.instytutpe.pl/en/eps-en/

e-ISSN: 2545-0859

The electronic version of the journal is the original version.

Rzeszow 2020

CONSTENTS

Andrzej Pacana, Dominika Siwiec

Using Decision-Making Tools to Analyse the Renewables in the Industrial Energetics Sector 3

Jakub Plebański

Legal Analysis of Support Schemes for Offshore Wind Farms in Poland, on the Basis of the Draft Act on Promoting Electricity Generation in Offshore Wind Farms............................... 15

Onyekwulu Millicent Chekwube, Ejaro Sunday Peter, Oguche Christopher Joseph, Diyoke Micheal Chika, Gwani Samuel, Jibo Magayaki Jamilu

Public Awareness and Perception of Socio-Economic Characteristic and Biogas in Gwagwalada Town Abuja, Nigeria 26

Grażyna Mórawska

The Renewable Energy in Baltic States versus Russian Federation Political Interests 48

Valero Tati

The Cold Gas War: the Strategies of Russia and the USA in Europe 56

Using Decision-Making Tools to Analyse the Renewables in the Industrial Energetics Sector

Andrzej Pacana, Dominika Siwiec

Abstract: As part of sustainable development is important to propagate and practice renewables. Therefore, the aim of the work was to proposed a tool to analyze the renewables in the context of their production volume and effectiveness in improving the natural environment. This tool was the AHP method (Analytic Hierarchy Process) which was integrated with numeral data about the production volume of electricity from renewables. It was shown that a proposed tool is useful to analyze the renewables and allows decided, which from renewables has the most influence on improving the natural environment. Therefore, the practice of the proposed tool supports the analysis, and undertaking adequate actions within the framework of sustainable development, in which enterprises producing and managing renewables.

Keywords: renewables, quality, industrial energy, industry, production engineering

Introduction

As part of actions the enterprises compatible with sustainable development, resulting from the industrial revolution (Industry 4.0) and actions providing well-being of society (Society 5.0), it is important entrepreneurship and innovation of enterprises (Piwowar, Dzikuc 2019: 1). However, this practice, despite economic progress and also energy-saving progress is still difficult, in view of the need for continuous electricity supply (Energetyka, raport końcowy z przeprowadzonych badań 2013: 15). Therefore, under sustainable development, the key is propagated and practiced renewables (Marks-Bielska et al. 2019: 2), which are contributed to reducing pollutants and greenhouse gases (Marks-Bielska et al. 2019: 2; Ochrona środowiska 2019: 101), in this the anthropological climate changes which arise from greenhouse gases (Bukosa et al. 2019: 7055; Wu, Mu 2019: 2; Zwoliński 2011: 6). This propagation and exploitation the renewables is accordance with Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 by Member States. Under Directive, the aim of Poland was to achieving a 15% share of electricity in final consumption (brutto) in Community (to the 2020 year), wherein Poland with 10,9% in 2017 was in the 21st position (Energia ze źródeł odnawialnych w 2018r. 2019: 13). In turn, comparing the volume of energy obtained by the European Union countries, in the 2005-2017 ratio, the largest increase was recorded on Cyprus (from 0,01 % to 9%), Estonia (from 1% to 17%), Belgium (from 2% to 17%) and United Kingdom (from 4% to 29%), wherein in Poland the increase was estimated from 2,7% to 13,1% (Energia ze źródeł odnawialnych w 2018r. 2019: 102). Despite this, Poland and also Malta, Hungary, Luksemburg, Cyprus are countries in which the share of electricity from renewable sources is relatively small. This aspect is important, in view of, that the country's primary energy demand is forecast to increase by 2030 up to 27% compared to 2010, with the share of renewable energy in total energy consumption increasing by 12% this year (i.e. 2020), and by 12.4% in 2030 (Marks-

Bielska et al. 2019: 2). Besides that, the significance of the issue of renewables is confirmed by numerous scientific publications. For example, authors of work (Piwowar, Dzikuc 2019: 1) were analyzed the possibility of using the biogas, wind farms and solar farms, in order to reduce greenhouse gases and increase energy efficiency. In turn, in work (Hassan, Kalam 2013: 39) was analyzed the biofuel based on rules and norms about biofuel and techniques in its processing, after which, it was concluded that there is still a need for their development, e.g. in the context of biofuel engines. Next, in work (Mudassar et al. 2020: 1, 8) it was analyzed the municipal wastes in context their production, progress and physical/chemical composition and assess their potential as renewables. In was shown, that burning 2000 tone of municipal wastes/day will allow on the recovery of the 48 MW energy, and in turn of contributes to improving the natural environment. By contrast, authors of work (Perkovic et al. 2016: 249), the flow of energy in complex energy systems, parallel to supply fresh water and electrical energy were modeled. It was shown, that under the proposed model, the increase of optimal range from 1 to 24 hours allows to reduce the surplus of electricity production by 80%, and increase of more than 5% renewables (in this case water).

After a review of the selected positions of subject literature, it was concluded that the issue of using renewables is the current research problem. It was analyzed the using renewables among others to restrictions emission of greenhouse gases or used to biofuel engines (Hassan, Kalam 2013: 39; Piwowar, Dzikuc 2019: 1). Also, it was analyzed among others to what extent using renewables sources will contribute to improving the environment (Mudassar et al. 2020: 1, 8; Perkovic et al. 2016: 249). However, it was considered, that one technique was not developed, which would be allowed to analyze the renewables in the context of production volume and effectiveness in improving the environment, what is a gap in making effective analysis of these aspects, and making right actions under sustainable development.

Therefore, the aim of the work was to proposed a tool to analyze the renewables in the context of their production volume and effectiveness in improving the environment. This tool was the AHP method (Analytic Hierarchy Process) which was integrated with numeral data about the production volume of electricity from renewables. In order to practice the possibilities of using the proposed tool, it was analyzed the current data (form 2018) about production volume electricity in main activity producer plans and autoproducer plants, which was obtained from a reliable source of statistical data, i.e. the Central Statistical Office (GUS).

Subject of the study

The subject of the study was a sector of main activity producer plants, in which produce and rotation of electricity is the main activity of the plants, and the sector of autoproducer plants, in which electricity is producing for needs the plants and is so-called side effect under production process (Energetyka, raport końcowy z przeprowadzonych badań, 2013:13). Selection of the subject of the study was resulted from context of the proposed technique, about including production volume of electricity from renewable energy sources.

Method

The proposed tool was the AHP method (Analytic Hierarchy Process) integrated with data about the production volume of electricity from renewables. Purpose of testing the proposed tool, figures on the volume of production in Poland for 2018 were obtained from a reliable source, i.e. the Central Statistical Office (GUS). Choice the AHP method (multi-criteria method of hierarchical analysis of decision problems) was resulted from their proven effectiveness in analyzed the qualitative and quantitative data (Horvathova et al. 2019: 2599; Saaty 2007: 860; Stoltmann 2016: 144). It was important in view of necessary the simultaneously analyze the qualitative data (production volume of electricity from renewables) and quantitative data (effectiveness in improving natural environment). In addition, AHP results are numerical values that are sometimes more favorable compared to attribute terms (Siwiec et al. 2019: 1594). In turn of choice of the data from GUS was conditioned by fact, that it is reliable and one of the main sources of data in Poland. The method of using the proposed tool was shown in 9 steps.

First step

The first step is to choose the goal. In this case, the aim was to indicate which of renewables in Poland in 2018 had the greatest impact on improving the state of the environment.

Second step

The second step is to choose the subject of the work. As part of the testing of the proposed tool, it were sectors: the main activity of the plants and autoproducer plants, which was characterized in part of the subject of study in this work. Due to the test nature of the analysis, these sectors were marked in random and conventionally from E1 to E2.

Third step

The third step is to choose renewables. As part of the testing of the proposed tool, it were:

- hydro,
- wind,
- solid biofuels ,
- municipal waste,
- biogas of landfill gas,
- biogas of sludge gas,
- other biogas,
- biopłyny,
- photovoltaics.

The renewables were selected based on the sets of production volumes of electricity from renewables in Poland in the 2018 year for main activity producers and autoproducers (Energia ze źródeł odnawialnych w 2018 r. Analizy statystyczne 2019: 84). Due to the fact that in 2018 in autoproducers was only recorded the hydro-1 MW, so the sum of production volumes this type of renewable was analyzed. Due to the test nature of the analysis, these renewables were marked in random and conventionally from R1-R9.

Fourth step

The fourth step is to make an assessment of production volumes of electricity from renewables. The assessment should be done separately for the main activity of the plants and for the autoproducer plants. The assessment is made by Saaty scale (adequate in AHP method), i.e.

1-9 (Stoltmann 2016: 144), where in the context of the proposed tool, grade 1 – smallest production volume, grade 9 – the biggest production volume. Rating are awarded by the entity using the tool, based on data about the production volume of electricity from renewables. In this case, it was data from GUS. In this case, the rating was awarded by the two people, i.e. the authors of work, which results from the test character of the proposed method.

Fifth step

The fifth step is to make an assessment of the effectiveness of renewables in improving the natural environment. Ratings are awarded by the entity using the tool in using the Saaty scale (1-9), where in this case: grade 1 – influence not very effective, and grade 9 – influence absolutely effective. In order for the grade would be reliable, it is important to be made by an expert, who will be based on knowledge and experience. However, under testing the proposed tool, the assessment was made in a subjective way by authors of the work.

Sixth step

The sixth step is to make a matrix of pairwise comparisons for a rating of production volumes and effectiveness. The matrix are so-called Saaty matrix, where on the diagonal there is always a rating equal to 1, which means that the given elements are equivalent, and above the diagonal, there are pairwise comparisons, in turn, under the diagonal are rating opposite (Horvathova et al. 2019: 2598).

Seventh step

The seventh step is to make a calculation and achieve the weight of production volumes and effectiveness of renewables, according to the AHP method whose detailed course is presented in works (for example Ammaarapala et al. 2018; Horvathova et al. 2019; Pacana, Siwiec 2018, Stoltmann 2016). After calculated it is necessary to check if the results do not violate the principle of constancy of preferences. In this aim it is necessary to calculate coherence factor λ_{max} (1), Consistency Index CI (2) and Consistency Ratio CR (3) (Horvathova et al. 2019: 2; Stoltmann 2016: 145):

$$\lambda_{max} = \frac{1}{w_i} \sum_{j=1}^{k} w_{ij} w_j \tag{1}$$

$$CI = \frac{\lambda_{max} - n}{r(n-1)} \tag{2}$$

$$CR = \frac{CI}{r} \tag{3}$$

where: n – number of renewables,

r – average random index value for n according to Saaty.

Full compliance of results is obtained when λmax = n, CI = 0, CR = 0. But, compliance is acceptable for λmax is close to n, for CI < 0,1 and CR < 0,1 (Ammaarapala et al. 2018: 33).

If there is a lack of full or acceptable compliance, the process should be repeated from step four until the results match.

Eighth step

The eighth step is to take into account the volume of production and the efficiency of renewable in order to indicate which renewable had the greatest impact on improving the state of the natural environment in Poland in 2018. Therefore, the weights of the production volume of two sectors (main activity of the plants and autoproducer plants) were multiplied by the weights of the efficiency of renewable. Next, the values obtained for a given renewable sector were added together.

Nine step

The ninth step is to point one renewable electricity, which had the greatest impact on improving the natural environment in Poland in the 2018 year. According to the proposed tool, it was an energy renewable with a maximum sum of weights.

The calculations of the AHP method can be performed using the applications supporting the AHP method, for example Matlab or Program R (Bartłomowicz 2016: 11; Zhang 2019: 10).

Results

The aim of testing the proposed tool was to indicate which of renewables in Poland in 2018 had the greatest impact on improving the state of the natural environment. The analyze was based on current data from the Central Statistical Office (Table 1).

Table 1. The set of production volumes of electricity from renewables in Poland in the 2018 year.

Specification		main activity producer plants	autoproducer plants
		GWh	
Hydro		1 966,7	3,3
Wind		12 798,8	-
Solid biofuels		3 617,0	1 716,2
Municipal waste		-	85,0
Biogas	Biogas of landfill gas	128,1	41,5
	Biogas of sludge gas	30,4	306,1
	Other biogas	462,8	158,8
Bioliquids		-	2,0
Photovoltaics		6,9	300,5

Source: Own study based on: Energia ze źródeł odnawialnych w 2018 r. Analizy statystyczne 2019: 84.

The assessment of the production volume of electricity from renewables was made based on Table 1, and then the calculation according to the AHP method was made (Table 2 and Table 3). Next, the assessment of the effectiveness of renewables in improving the natural environment was made, after it, the calculation according to the AHP method was made (Table 4). The Rx marks used in Tables 2-4 were used randomly based on Table 1, it was resulting from the test character of analysis and also from individual assessments of authors of work, who aimed only shown the effectiveness and usefulness of proposed a tool to analyze the renewables in the context of their production volume and effectiveness in improving the natural environment. So, after calculation, the full compliance of results was obtained, i.e. $\lambda max = n = 9$ (where n – number of renewables), CI = 0, CR = 0, and average random index value for n = 9 was 1, 45 (Ammaarapala et al. 2018: 33). In part of proposed tool, the values were unified by multiplied the weights for production volume and effectiveness of renewables (Table 5), after it, it was possible to indicated which of renewables in Poland in 2018 had the greatest impact on improving the state of the natural environment. It was renewable electricity with the conventional designation R9.

It is necessary to remember that result from the analysis is objective, but the assessment of each criterion which was made by authors of the work were subjective, so the results of the analysis may vary.

Table 2. The result of the analysis for the sector designated E1.

E1	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**E1**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**
R1	1,00	9,00	1,50	2,25	1,80	4,50	3,00	9,00	1,29	**R1**	0,23	0,24	0,24	0,24	0,24	0,24	0,24	0,23	0,11
R2	0,11	1,00	0,17	0,25	0,20	0,50	0,33	1,00	0,14	**R2**	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,01
R3	0,67	6,00	1,00	1,50	1,20	3,00	2,00	6,00	0,86	**R3**	0,15	0,16	0,16	0,16	0,16	0,16	0,16	0,15	0,08
R4	0,44	4,00	0,67	1,00	0,80	2,00	1,33	4,00	0,57	**R4**	0,10	0,11	0,11	0,11	0,11	0,11	0,11	0,10	0,05
R5	0,56	5,00	0,83	1,25	1,00	2,50	1,67	5,00	0,71	**R5**	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,06
R6	0,22	2,00	0,33	0,50	0,40	1,00	0,67	3,00	0,29	**R6**	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,08	0,03
R7	0,44	3,00	0,50	0,75	0,60	1,50	1,00	3,00	0,43	**R7**	0,10	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,04
R8	0,11	1,00	0,17	0,25	0,20	0,50	0,33	1,00	0,14	**R8**	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,01
R9	0,78	7,00	1,17	1,75	1,40	3,50	2,33	7,00	7,00	**R9**	0,18	0,18	0,18	0,18	0,18	0,18	0,18	0,18	0,61
Sum	**4,33**	**38,00**	**6,33**	**9,50**	**7,60**	**19,00**	**12,67**	**39,00**	**11,43**	**Sum**	**2,00**	**0,22**	**1,33**	**0,89**	**1,11**	**0,47**	**0,69**	**0,22**	**2,08**
										Weight	**0,22**	**0,02**	**0,15**	**0,10**	**0,12**	**0,05**	**0,08**	**0,02**	**0,23**
λ_{max} = n = 9					CI = 0								CR = 0						

Source: Own study.

Table 3. The result of the analysis for the sector designated E2.

E2	R1	R2	R3	R4	R5	R6	R7	R8	R9	E2	R1	R2	R3	R4	R5	R6	R7	R8	R9
R1	1,00	0,25	0,50	0,33	0,20	0,17	0,14	0,50	0,11	**R1**	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
R2	4,00	1,00	2,00	1,33	0,80	0,67	0,57	2,00	0,44	**R2**	0,10	0,11	0,10	0,10	0,10	0,10	0,10	0,10	0,10
R3	2,00	0,50	1,00	0,67	0,40	0,33	0,29	1,00	0,22	**R3**	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05
R4	3,00	0,75	1,50	1,00	0,60	0,50	0,43	1,50	0,33	**R4**	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
R5	5,00	1,25	2,50	1,67	1,00	0,83	0,71	2,50	0,56	**R5**	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,13
R6	6,00	1,50	3,00	2,00	1,20	1,00	0,86	3,00	0,67	**R6**	0,15	0,16	0,15	0,15	0,15	0,15	0,15	0,15	0,15
R7	7,00	1,50	3,50	2,33	1,40	1,17	1,00	3,50	0,78	**R7**	0,18	0,16	0,18	0,18	0,18	0,18	0,18	0,18	0,18
R8	2,00	0,50	1,00	0,67	0,40	0,33	0,29	1,00	0,22	**R8**	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05
R9	9,00	2,25	4,50	3,00	1,80	1,50	1,29	4,50	1,00	**R9**	0,23	0,24	0,23	0,23	0,23	0,23	0,23	0,23	0,23
Sum	**39,00**	**9,50**	**19,50**	**13,00**	**7,80**	**6,50**	**5,57**	**19,50**	**4,33**	**Sum**	**0,23**	**0,93**	**0,46**	**0,69**	**1,16**	**1,39**	**1,59**	**0,46**	**2,08**
										Weight	**0,03**	**0,10**	**0,05**	**0,08**	**0,13**	**0,15**	**0,18**	**0,05**	**0,23**
λ_{max} = n = 9					CI = 0									CR = 0					

Source: Own study.

Table 4. The result of the analysis for renewables.

R	R1	R2	R3	R4	R5	R6	R7	R8	R9	R	R1	R2	R3	R4	R5	R6	R7	R8	R9
R1	1,00	1,00	1,17	0,67	1,75	0,88	1,40	1,75	0,88	**R1**	0,12	0,12	0,13	0,11	0,12	0,12	0,12	0,12	0,11
R2	1,17	1,00	1,17	0,78	1,75	0,88	1,40	1,75	0,88	**R2**	0,14	0,12	0,13	0,12	0,12	0,12	0,12	0,12	0,11
R3	0,86	0,86	1,00	0,67	1,50	0,75	1,20	1,50	0,75	**R3**	0,10	0,10	0,11	0,11	0,10	0,10	0,10	0,10	0,09
R4	1,29	1,29	0,78	1,00	2,25	1,13	1,80	2,25	1,13	**R4**	0,15	0,16	0,09	0,16	0,16	0,16	0,16	0,16	0,14
R5	0,57	0,57	0,67	0,44	1,00	0,50	0,80	1,00	0,50	**R5**	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,06
R6	1,14	1,14	1,33	0,89	2,00	1,00	1,60	2,00	1,00	**R6**	0,14	0,14	0,15	0,14	0,14	0,14	0,14	0,14	0,12
R7	0,71	0,71	0,83	0,56	1,25	0,63	1,00	1,25	0,63	**R7**	0,08	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,08
R8	0,57	0,57	0,67	0,44	1,00	0,50	0,80	1,00	0,50	**R8**	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,06
R9	1,14	1,14	1,33	0,89	2,00	1,00	1,60	2,00	2,00	**R9**	0,14	0,14	0,15	0,14	0,14	0,14	0,14	0,14	0,24
Sum	**8,45**	**8,29**	**8,94**	**6,33**	**15**	**7,25**	**11,60**	**14,50**	**8,25**	**Sum**	**1,06**	**1,10**	**0,93**	**1,31**	**0,62**	**1,24**	**0,77**	**0,62**	**1,36**
										Weight	**0,12**	**0,12**	**0,10**	**0,15**	**0,07**	**0,14**	**0,09**	**0,07**	**0,15**
λ_{max} = n = 9					CI = 0									CR = 0					

Source: Own study.

Table 5. Results of integrated production volume and effectiveness of renewables.

Symbol of renewables	Weight			Production volume and efficiency			Maxiumum weight (the greatest impact on improving the state of the natural environment)
	Production volume		Efficiency				
	E1	E2		Weight		Sum of weight	
R1	0,22	0,03	0,12	0,03	0,00	0,03	R9 = 0,07
R2	0,02	0,10	0,12	0,00	0,01	0,02	
R3	0,15	0,05	0,10	0,02	0,01	0,02	
R4	0,10	0,08	0,15	0,01	0,01	0,03	
R5	0,12	0,13	0,07	0,01	0,01	0,02	
R6	0,05	0,15	0,14	0,01	0,02	0,03	
R7	0,08	0,18	0,09	0,01	0,02	0,02	
R8	0,02	0,05	0,07	0,00	0,00	0,01	
R9	0,23	0,23	0,15	0,03	0,03	0,07	

Source: Own study.

Conclusions

The aim of the work was to proposed a tool to analyze the renewables in the context of their production volume and effectiveness in improving the environment. This tool was the AHP method (Analytic Hierarchy Process) which was integrated with numeral data about the production volume of electricity from renewables. In order to practice the possibilities of using the proposed tool, it was analyzed the current data (form 2018) about production volume electricity in main activity producer plans and autoproducer plants, which was obtained from a reliable source of statistical data, i.e. the Central Statistical Office (GUS). The analysis was indicated electricity renewable, which in the context of the proposed tool had the greatest impact on improving the state of the natural environment (in the case of Poland on the 2018 year). It was renewable electricity with the conventional designation R9. Despite the results may vary, what is resulting from the assessment of the entity who is using the tool (i.e. authors of work), it was shown that this tool is effective in case the analysis of production volume and effectiveness of electricity renewable. Therefore, the practice of the proposed tool supports the analysis, and undertaking adequate actions within the framework of sustainable development, in which enterprises producing and managing renewable energy sources.

Bibliography

1. Ammaarapala V., Chinda T., Pongsayaporn P., Ratanachot W., Punthutaecha K., Janmonta K., *Cross-border shipment route selection utilizing analytic hierarchy process (AHP) method*, „Songklanakarin J. Sci. Technol." 40(1) (2018).
2. Bartłomowicz T. *Analiza porównawcza pakietów metody Analytic Hierarchy Process Programu R*, „*Business Informatic"* 3(41) (2016).
3. Bukosa B., Deutscher N. M., Fisher J. A., Kubistin D., Paton-Walsh C., Griffith D. W., *Simultaneous shipborne measurements of CO2, CH4 and CO and their application to improving greenhouse-gas flux estimates in Australia,* "Atmospheric Chemistry And Physics" 19(10) (2019).
4. *Energetyka*. *Raport końcowy z przeprowadzonych badań*, Bilans kompetencji branży. Kraków (2013).
5. *Energia ze źródeł odnawialnych w 2018 r. Analizy statystyczne*. Główny Urząd Statystyczny, Warszawa (2019).
6. Hassan M. H., Kalam M. A., *An overview of biofuel as a renewable energy source: development and challenges, „*Procedia Engineering" 56 (2013).
7. Horvathova P., Copikova A., Mokra K. *Methodology proposal of the creation of competency models and competency model for the position of a sales manager in an industrial organisation using the AHP method and Saaty's method of determining weights*, „Economic Research-Ekonomska Istrazivanja", 32(1) (2019).
8. Marks-Bielska R., Bielski S., Novikova A., Romaneckas K., *Straw Stocks as a Source of Renewable Energy. A Case Study of a District in Poland, „S*ustainability" 11(17) (2019).
9. Mudassar A., Saman S. J., Waseem R., Nadeem R., Sang S. L., *Status characterization, and potential utilization of municipal solid waste as renewable energy source: Lahore case study in Pakistan, „*Environment International" 134 (2020).
10. *Ochrona środowiska 2019. Analizy statystyczne*. Główny Urząd Statystyczny, Warszawa (2019). Publikacja dostępna na stronie: stat.gov.pl (dostęp: 29.04.2020).

11. Pacana A., Siwiec D. *Dobór maszyny z wykorzystaniem drzewa decyzyjnego i metody AHP,* „Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie" 131 (2018).
12. Perkovic L., Novosel T., Puksec T. i in. *Modeling of optimal energy flows for systems with close integration of sea water desalination and renewable energy sources: Case study for Jordan*, „Energy Conversion And Management" 110 (2016).
13. Piwowar A., Dzikuc M. *Development of Renewable Energy Sources in the Context of Threats Resulting from Low-Altitude Emissions in Rural Areas in Poland: A Review, „*Energies" 12(18) (2019).
14. Saaty T. L., *Time dependent decision-making; dynamic priorities in the AHP/ANP: Generalizing from points to functions and from real to complex variables,* „Mathematical And Computer Modelling" 46(7-8) (2007).
15. Siwiec D., Bednarowa L., Pacana A., Zawada M., Rusko M. *Wspomaganie decyzji w procesie doboru penetrantów fluorescencyjnych do przemysłowych badań nieniszczących,* „Przemysł Chemiczny", 98(10) (2019).
16. Stoltmann A., *Application of AHP Method for Comparing the Criteria Used in Locating Wind Farms,* „Acta Energetica" 3(28) (2016).
17. Wu B., Mu C. *Effects on Greenhouse Gas (CH4, CO2, N2O) Emissions of Conversion from Over-Mature Forest to Secondary Forest and Korean Pine Plantation in Northeast China,* „Forests*"*10(9) (2019).
18. Zhang W. J. Analytic Hierarchy Process (AHP): Matlab computation software, „*Network Biology"* 9(1) (2019).
19. Zwoliński Z., *Globalne zmiany klimatu i ich implikacje dla rzeźby Polski*, „Landform Analysis" 15 (2011).

Andrzej Pacana, DSc, PhD, Eng., Associate Prof., works in the Department of Machine Technology and Production Engineering, Faculty of Machinery and Aviation Construction of Rzeszow University of Technology. Scientific interests include issues related to quality management, environment and work security, logistics and quality engineering. He is an expert in providing consulting services in the area of management systems - he acts as a reviewer, trainer, lecturer and speaker at numerous seminars, open and closed trainings.
ORCID: 0000-0003-1121-6352

Dominika Siwiec, M.Sc., works in the Department of Machine Technology and Production Engineering, Faculty of Machinery and Aviation Construction of Rzeszow University of Technology. She is currently on the second year of doctoral studies in the discipline of Machine Building and Operation. Scientific interests include an area of quality engineering and manufacturing engineering.
ORCID: 0000-0002-6663-6621

Legal Analysis of Support Schemes for Offshore Wind Farms in Poland, on the Basis of the Draft Act on Promoting Electricity Generation in Offshore Wind Farms

Jakub Plebański

Abstract: The main objective of the study concerns the legal analysis of support schemes for electricity producers, according to the published draft act on the promotion of electricity generation in offshore wind farms in Poland. Taking into account the specificity of energy production from renewable energy sources, the application of the support scheme is of key importance for popularization of investments in a particular type of installation, in the discussed case, in offshore wind farms. The research methods applied by the author are based on formal-dogmatic, linguistic and logical methods. Commenting on the introduced legal changes, the author also considered aspects of economic analysis of the law, discussing the usefulness of the proposed solutions for the development of the offshore wind energy industry. The attention should be paid to the ambitious goals set by the legislator in connection with the development of this industry, which include avoiding a generation gap in the national power system and the fulfilment of the EU energy and climate commitments by Poland. The draft act under analysis takes into account two phases of the offshore wind farm support scheme, both based on a bilateral model of a contract for difference. If the quoted draft act is passed, it will be an important step towards the promotion of electricity generation in offshore wind farms in Poland.

Keywords: offshore wind farms, support schemes, renewable energy sources, power generation, unconventional energy

Introduction

The purpose of the study is to assess and analyze the support schemes for electricity producers on the basis of the draft act on the promotion of electricity generation in offshore wind farms published by the Minister of State Assets of Poland. Furthermore the study points out the differences concerning primarily the way how the public support is granted to producers operating in offshore wind farms. The aforementioned draft act is of key importance in terms of the future development of Polish offshore wind energy and the legislative initiative in this respect should be assessed unequivocally positively. According to the draft act, producers are to obtain the right to participate in a two-phase support system based on the contract for difference model. The regulations partially reflect the auction system, which has been functioning so far in relation to other types of renewable energy sources in Poland, and as statistics show, is already an optimal form of support for onshore wind farms in Poland. (Diallo, Dézsi, Bartek-Lesi, Mezősi, Szajkó, Kácso, Szabó 2018: 20) Therefore the application of contract for difference model for future offshore wind farms in Poland deserves to be favourably remarked and raises justified hopes that the commented legal act will enable rapid development of offshore wind energy in Poland. The current international obligations of the Republic of Poland require legislation which particularly stimulates the development of offshore wind farms. According to

Directive 2009/28/EC, Poland must ensure a minimum 15% share of energy from renewable sources in gross final energy consumption in 2020. This obligation is reinforced by Article 3(4) of Directive 2018/2001 introducing an obligation to maintain the share of renewable energy sources in gross final consumption of energy of not less than 15 % after 2020. However, Poland's achievement of this energy target is not certain, what is evidenced by changes in governmental assumptions. Adopted by the Council of Ministers in 2009. The "National Renewable Energy Action Plan" set the expected rate of use of energy from renewable sources in 2018 at 13.79%, (Ministerstwo Gospodarki 2010: 19) while according to the published document "Energy Policy of Poland until 2040", in 2018 the share of renewable sources in the balance of energy consumption was only 10.9%. (Ministerstwo Energii 2019: 52) It should also be taken into account that, in the long term, Poland cannot stop at achieving a 15% share of renewable energy sources in gross final consumption of energy, as Article 3(1) of Directive 2018/2001 provides a new binding EU target for the share of energy from renewable sources in the European Union in gross final consumption of energy in 2030 of at least 32%, under which Poland declares to achieve a level of 21-23% of the share of renewable energy sources in gross final consumption of energy. (Ministerstwo Energii 2019: 52) Achieving the above targets requires taking steps to enable a rapid increase in the capacity installed in renewable energy sources. Such a result can be achieved, among other things, thanks to the development of offshore wind farms, enabling the production of electricity from a renewable energy source (wind power) on a very large scale. (Drożdż, Mróz-Malik 2017: 151-152) A special pro-development impulse for the development of offshore wind energy production in Poland may be the support schemes described in the discussed draft act. According to Article 2(k) of Directive 2009/28/EC, the term "support scheme" is understood as an instrument, system or mechanism applied by a Member State or a group of Member States which promotes the use of energy from renewable sources by reducing the cost of such energy, increasing the price for which it can be sold, or increasing - by imposing an obligation to use renewable energy or otherwise - the amount of energy purchased.

The existing regulations on offshore wind farms in the Polish legal system

So far, the issue of offshore wind energy has been regulated by the basic Polish law on renewable energy sources, i.e. the Act of 20 February 2015 on Renewable Energy Sources, but it cannot be assessed as a regulation sufficient for its development. The current legislation should be evaluated as not adapting the support schemes to the specificities of energy production in offshore wind farms. This concerns, in particular, provisions on how installations of different types of renewable energy sources should compete for granting the public support. Under the current rules, offshore wind farms are subject to the auction scheme under which they would have to compete with hydro or bioliquid installations for public support. (Article 73(3a) of the Act on Renewable Energy Sources). However, such a solution does not take into account far-reaching differences in the generation potential of offshore wind farms in comparison to other renewable sources, as well as significant differences in the price of electricity produced in those sources. Moreover the implementation of the investment schedule for offshore wind farms differs significantly from that used for other renewable energy installations. Therefore, it is not surprising that according to the explanatory memorandum to the draft act on the promotion of electricity generation in offshore wind farms, the current regulations do not correspond to the legal and factual situation of offshore wind farms and do not stimulate this type of investments to a sufficient degree, which prevents the development and operation of offshore wind farms within the National Power System. (Ministry of Energy 2019: 55) This applies in particular to the support systems for offshore wind energy. Despite the formal possibility of including offshore wind farms in the existing auction system regulated by the Renewable Energy Sources Act, the legislator rightly pointed out that "the currently envisaged fifteen-year support period does not provide sufficient investment incentive as it is much shorter than the total lifetime of an offshore wind farm and does not allow the investor to obtain an adequate return on capital employed". It is therefore a rational idea to design and regulate the individual support system for offshore wind farms into a separate legal act.

Another legal act significantly affecting the legal situation of offshore wind farms in Poland is the Act of March 21, 1991 on maritime areas of the Republic of Poland and maritime administration, which regulates, among others, key issues for investment process i.e. erecting artificial islands and locating of offshore wind farms. According to Article 23(1a) of the Act construction and operating of offshore wind farms in internal waters and territorial sea is prohibited. The reasons for this provision refers, inter alia, to issues of maritime safety, the aesthetics of coastal areas and the harmful effects of wind installations on the immediate surroundings. (Herdzik 2018: 52-52). However, such a restrictive regulation should be criticised as inflexible (fixed minimum distance criterion) and potentially limiting the safeness of offshore wind farms in Poland. Due to the fact that offshore wind farms can be established only outside of Polish territorial waters consequently they cannot become an element of the European critical infrastructure. (Miętkiewicz 2019: 104) It leads to the conclusion that in the light of current legislation, despite the significant potential of electricity production and strategic advantages for the state interest, offshore windfarms will not be covered by the security procedures at the same level as in reference to onshore plants. On the other hand, it is worth appreciating that despite the fact that offshore wind farms are not part of the European critical infrastructure, this problem has been addressed in the “Strategic concept of maritime security of the Republic of Poland” . According to the document, projects related to offshore wind farms, as an aspect of Polish energy security, should be protected or shielded by the Polish Navy forces at all stages of their implementation, the protection also applies to the shipbuilding industry working for offshore wind energy sector. (Strategic concept of maritime security of the Republic of Poland 2017: 49). However, the issue of the safeness of offshore wind farms cannot be narrowed only to military issues alone, that is why the further legislative activity in this area should be postulated.

The right to cover the negative balance by electricity producers in offshore wind farms as a result of an individual decision of the President of the Energy Regulatory Office

In Article 4 of the draft act on the promotion of electricity generation in offshore wind farms, the legislator provided for the right of producers to cover the negative balance with regard to energy generated in offshore wind farms and introduced into the grid. The principles of settlement of the negative balance were regulated in Article 32(1)(3) of the draft act. The negative balance constitutes the difference between the value of electricity generated in the offshore wind farm and fed into the grid, calculated on the basis of average market prices, and the value of that energy resulting from the decision on granting the producer the right to cover the negative balance issued by the President of the Energy Regulatory Office. It should be pointed out that for the purpose of the decision on granting support, the President of the Energy Regulatory Office sets the price of electricity per 1 MWh based on the rates given in the Ordinance issued yearly by the minister competent for energy, separately for the producers who received support in each calendar year until 2022. The legislator has therefore decided to use the mechanism of the bilateral contract for difference (Długosz 2018: 280), which has so far operated as an element of the auction system under the Renewable Energy Sources Act, for (in practice: other than offshore wind farms) installations with a total installed electrical capacity of not less than 500 kW pursuant to Article 93(2) of the Renewable Energy Sources Act, which should be evaluated as a positive regulation in light of experience of this model functioning in Poland to date. A state-owned company, Zarządca Rozliczeń S.A., was established as the settlement operator obliged to cover the negative balance by referring to Article 106 of the Renewable Energy Sources Act. It is worth noting that, unlike other installations of renewable energy sources, the legislator has reserved the minimum amount of energy in MWh, which the producer is entitled to apply for the right to cover the negative balance each time. According to Art. 7(1) of the draft act it is the product of 100 000 hours and the installed capacity of the offshore wind farm or its part resulting from the concession for the production of electricity.

Pointing out the differences between the auction system that has been functioning for other than offshore wind farms renewable energy sources in Poland so far and the discussed new mechanism of covering the negative balance, on the basis of the draft act on the promotion of electricity generation in offshore wind farms, first of all, attention should be paid to the mode of granting support. Pursuant to Article 15 par. 1 of the draft act, the right to cover the negative balance results from an individual decision issued by the President of the Energy Regulatory Office at the request of the energy producer in an offshore wind farm. The said decision determines the price which is the basis for the settlement of the negative balance during the whole period of support for the producer, which is 25 years, being 10 years longer than in the case of the auction system. The start of the 25-year support period is inaugurated "from the first day of generation and feeding into the grid of electricity from this offshore wind farm or part of it on the basis of an electricity generation concession". An offshore wind farm means the installation of a renewable energy source, which includes one or more offshore wind turbines. Therefore, taking into account the scale of the offshore wind farm projects, the question arises as to the duration of the period in which the producer is entitled to cover the negative balance if the individual turbines, consisting of an offshore wind farm, will be commissioned at different dates and stages. The wording of the provision leads to the conclusion that the 25-year period of support for the installation will be shortened by the difference between the date of generation and introduction of electricity from the first and the last turbine comprising a given offshore wind farm to the grid. However, the legislator assumed that when a producer builds and commissions an offshore wind farm in stages, the amount of energy for which the producer has the right to apply for coverage of the negative balance is calculated on the basis of each installed capacity of the offshore wind farm resulting from the electricity generation concession issued to the producer for the completed stages of construction.

In this form, the provisions on the support scheme for offshore wind farms should be assessed as exceptionally preferential compared to the auction support scheme for renewable energy sources, where support is not granted at the individual request of a producer but is based on competition between producers based primarily on price criteria. It should be assumed that such a favourable regulation is due to a significant limitation, both in terms of subject matter and time, of the availability of this support scheme for offshore wind farms. According to Article 5 (1) of the draft act, the President of the Energy Regulatory Office may issue a decision to grant support only to offshore wind farms whose total installed capacity will not exceed 4600 MW. On the other hand, as stipulated in Article 5 (2) of the draft act, the order in which the right to cover the negative balance will be granted will be determined by the order in which the applications are submitted, and the decisions on granting support, for complete applications submitted not later than September 30, 2022, will be issued by December 31, 2022. It should be emphasized that in the context of the dynamics of the investment process related to the development of an offshore wind farm project, it is not a distant time, and the legislator allowed the possibility of obtaining support only for projects at an advanced level of development. This was regulated in Article 13 (3) of the draft act, which includes a catalogue of documents that must be obtained in order to effectively apply for support in the form of an individual decision to cover the negative balance. According to the aforementioned provision, the possibility of obtaining support refers only to those offshore wind farm projects which by December 31, 2022 will obtain, among others, an agreement on the connection of the offshore wind farm to the transmission or distribution grid, a decision on environmental conditions, as well as a valid permit for the erection and use of artificial islands, structures and equipment in Polish maritime areas for projects located in the exclusive economic zone. By far the third criterion quoted is the most restrictive. Pursuant to the decision of 3 February 2017 issued by the Minister of Maritime Economy and Inland Navigation, on the basis of Article 23 (8) of the Act on Maritime Areas of the Republic of Poland and maritime administration, pending and new administrative proceedings in the field of permits for erection or use of artificial islands, structures and equipment in Polish maritime areas have been suspended until the adoption, by way of a regulation, of spatial development plans for internal sea waters, territorial sea and exclusive economic zone. Pursuant to Directive 2014/89/EU of the European Parliament and of the Council establishing a framework for maritime spatial planning, the deadline for its adoption is 31 March 2021. Taking into account that as of the date of publication of the draft act on the promotion of electricity generation in offshore wind farms, the said plan has not been adopted, it should be stated that the possibility of obtaining support in the form of an individual decision to grant the producers the right to cover the negative balance, applies only to projects which obtained a permit to erect and use artificial islands, structures and equipment before 3 February 2017. By reason of the above, the thesis that the scrutinized mechanism was envisaged only for a narrow group of entities with the highest level of investment process advancement and will constitute a specific kind of bonus for early generation of electricity, seems justified. Taking into account the expectations concerning the rate of capacity growth in connection with the implementation of investments in offshore wind farms in Poland, such a significant limitation deserves a negative assessment. Moreover, this raises doubts in the context of Article 107 of the Treaty on the Functioning of the European Union, which prohibits aid granted by Member States or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods, in so far as it affects trade between Member States. Within the framework of the case law of the Court of

Justice of the European Union, the following elements constitute State aid: (a) advantage, (b) selectivity, (c) State resources, (d) effect on trade between Member States. (Kurcz 2012: Lex) All these elements are corresponding to the support scheme, therefore, in Article 6(1) of the draft act the legislator stipulated that the commencement of the period in which a producer of electricity in an offshore wind farm may use the right to cover the negative balance is subject to the issuance of a decision on the compatibility of the granted public aid with the internal market, pursuant to Article 31(1) of the draft act. Another mechanism adapting the discussed system of support to the EU rules related to granting public aid is the examination of the incentive effect. The incentive effect means that, as a result of the State measure, the aid beneficiary is expected to undertake activities which are desirable from the point of view of the public authorities and which it would not undertake in the normal course of its business. The incentive effect therefore is applied to assess whether the objective of the State intervention could be achieved through a market mechanism or whether the state aid was needed for specific investment objectives. (Kociubiński 2012: 18) Article 10 (1) of the draft act makes the granting of the right to cover the negative balance to the producers dependent upon obtaining official confirmation of the incentive effect from the President of the Energy Regulatory Office. It is issued on the basis of the technical and economic description of the planned offshore wind farm investment. The main task of the President of the Energy Regulatory Office is to decide whether the investment could be implemented if the producer was not granted support in the form of the right to cover the negative balance. Otherwise, the granted support would be qualified as operating aid for the entrepreneur, incompatible with Article 107(3) of the Treaty on the Functioning of the European Union. (Kociubiński 2012: 18)

The quoted support scheme, in the form of individual granting of the right to cover the negative balance to producers, as intended by the legislator, is to constitute the first phase of support for the most advanced offshore wind farm projects with a total capacity of no more than 4.6 GW. According to the explanatory memorandum of the draft act, this preferential support scheme is to ensure rapid growth of electricity production from zero-emission sources, which will have an impact not only on Poland's fulfilment of its obligations under EU directives, but may also contribute to the mitigation of the risk of a generation gap, i.e. a capacity shortfall against demand. (Polskie Sieci Elektroenergetyczne 2016, Urząd Regulacji Energetyki 2019) The estimated potential for development of offshore wind farms in Poland, however, far exceeds the aforementioned 4.6 GW, and according to the announcements of the Government Plenipotentiary for Renewable Energy Sources, being estimated between 8 and 10 GW in 2040. (Ministry of Climate 2020) Therefore, the draft act on the promotion of electricity generation in offshore wind farms provides for the functioning of the second support scheme, going beyond the above-mentioned 4.6 GW of installed capacity by the end of 2022.

Auctions for offshore wind farms

According to the intention of the legislator, the second phase of support for offshore wind farms will be an auction system. The basic assumption of the auction system is that investors in competitive tenders will apply for a long-term differential contract for the sale of electricity. (Pawełczyk 2017: 36) It should be emphasized that the auctions for offshore wind farms will be autonomous from the auctions organized so far on the basis of Article 69a of the Act on Renewable Energy Sources. This means not only the technical regulation of auctions for offshore wind farms in a separate legal act, but also, according to the principle that electricity generated in a given renewable energy sources installation may use only one support scheme at a time (Przybylska 2019: Lex) the possibility for offshore wind farms to use only the auction system covered by the draft act. According to the legislator's assumptions, auctions will be organised in the "pay as bid" model. This means that the producer selling electricity on the market is entitled to cover the negative balance, i.e. the difference between the price for electricity resulting from the auction offer and the price for which it managed to sell electricity on the market. It seems that an interesting alternative to the 'pay as bid' auction system could be to use the 'pay as clear' model. According to the 'pay as clear' principle, once the auction is settled, all successful bidders can exercise their right to cover the negative balance established in relation to the highest price chosen at the auction. In this way, all beneficiaries of the auction theoretically could benefit from the same scope of support after the end of the tender procedure. (Capacity mechanism working group 2015: 4) The "pay as bid" system induces higher risks for producers as it clearly favours producers making higher bids. (Capacity mechanism working group 2015: 4) As a rule, the higher the accepted energy price, the potentially higher the value resulting from the right to cover a negative balance. A regulatory solution that limits this mechanism, leading to a reduction of differences between the auction bids, is the publication by the minister competent for energy of ordinance on reference prices. In accordance with Article 22 (1) of the draft act, the reference price is the maximum price in PLN per 1 MWh that may be indicated in the bids submitted in the auction by producers producing electricity in offshore wind farms. Bids submitted in the auction with the price exceeding the reference price are rejected pursuant to Article 25 (9) of the draft act. By the ordinance minister competent for energy is obliged to aim at the state energy policy, security of the power system, international obligations, environmental protection issues, technical and economic parameters of the operation of offshore wind farms, operating and investment costs related to the offshore wind farm project, justified return on capital employed for investment, as well as economic and social considerations (Article 22 (2) of the draft Act). In this context, it should be stated that the regulation on reference prices is an important tool providing elasticity to the energy market situation for offshore wind farms.

The interesting solution, applied in the draft act on promotion of electricity generation in offshore wind farms, is the indication by the legislator of specific calendar years in which the President of the Energy Regulatory Office is obliged to organise auctions for offshore wind farms in the future. Moreover, the legislator indicated the maximum total installed electric power of the offshore wind farms, in relation to which the right to cover the negative balance during each of these auctions may be granted. According to the draft act, the first auction for offshore wind farms is to take place in 2023, and the contractable capacity will be the difference between 4600 MW and the total installed electric capacity of the offshore wind farms, for which the President of the Energy Regulatory Office has previously issued an individual decision to grant the right to a negative balance (by the end of 2022), provided that the difference is it is at least 500 MW. Consequently the range of the first auction for offshore wind farms has been closely linked to the effectiveness and, in principle, the widespread use of the first support phase. Subsequent auction sessions are planned for 2025 and 2027, establishing that in both cases the total installed capacity of the contracted offshore wind farms will not exceed 2.5 GW. The legislator also allowed the auction in 2028 if the total capacity resulting from the bids submitted in the 2027 auction turns out to be lower than the maximum value of the capacity allocated for this auction, provided that the difference is at least 500 MW. The draft act also provides a solution whereby the difference between the maximum installed capacity of wind farms for a specific auction and the actual capacity resulting from the bids that won the auction increases the maximum installed capacity of offshore wind farms for which the right to cover the negative balance at the next auction may be granted. However, the above parameters concerning the installed capacity of the offshore wind farms receiving the right to cover the negative balance as a result of the auction decision, described in the draft act, may be changed by issuance an ordinance of the Council of Ministers related to the security of operating of the National Power System. It should also be mentioned that there is a possibility under Article 23(7) of the draft act to arrange additional auctions not included in the statutory schedule, organised additionally by way of an ordinance of the Council of Ministers by 30 April of each calendar year.

This transparent way of organizing auctions included in the draft act should be appreciated, as it directly affects the investment certainty related to offshore wind farms. The advantages of this solution are understood against the background of the current way of organizing auctions for other renewable energy installations. Although, in accordance with Article 73(1) of the Renewable Energy Sources Act, the President of the Energy Regulatory Office is obliged to organise them annually, the maximum amount and value of electricity from renewable energy sources that can be sold by auction is each time regulated by separated ordinance. The Act on Renewable Energy Sources does not even indicate the minimum value of electricity that may be specified in this regulation. It leads to the conclusion that within the ordinance the Council of Ministers may set the amount and value of electricity at PLN 0 and 0 megawatt hours, for all or some categories of renewable energy source installations entitled to participate in auctions. (Muszyński 2020: Legalis) so, the guarantee of annual auctions does not provides possibility for producers to participate in them. This problem has been effectively solved in the draft act on promoting electricity generation in offshore wind farms, where the schedule and the capacity are transparently included in the draft act. The regulation, which in turn may lead to the limitation of application of the auction system for offshore wind farms, is Article 24 (6) of the draft act, stipulating that the auction shall not be settled if less than three bids meeting the requirements presented in the act have been submitted. As one of the requirements for the President of the Energy Regulatory Office to issue the certificate of admission to the auction is the presentation by the producer a valid permit for the erection and use of artificial islands, constructions and equipment in Polish maritime areas for projects located in the exclusive economic zone, it can be concluded that the development of the auction system for offshore wind farms depends on two circumstances, i.e. first of all, the scale of support granted to the producers under the first phase until the end of 2022, and secondly, the awaited adoption of the spatial development plan for internal sea waters, territorial sea and the exclusive economic zone and then the dynamics of investment activities.

The factor which stimulating the dynamism of the offshore investments in Poland can be the extended period during (comparing to other installations of renewable energy sources) in which the producer, as the winner of the auction, is entitled to cover the negative balance. According to Article 30 (2) in connection with Article 6 of the draft act, the right to cover the negative balance is vested to the winners of the auction for a period of 25 years, counting from the first day of generation and introduction of electricity from the offshore wind farm or its part to the grid on the basis of the obtained license for the generation of electricity. The method of settlement of the right to the negative balance by the auction winners for offshore wind farms is analogous to the first phase of the support scheme presented above. Similarly, the state-owned company Zarządca Rozliczeń S.A. was established as the settlement operator. The provisions concerning the rigidly determined amount of energy in MWh, with respect to which the producer has the right to apply for coverage of the negative balance (product of 100 000 hours and from the installed capacity of the offshore wind farm or its part resulting from the license for the generation of electricity) are also applicable here.

Summary

The draft act on the promotion of electricity generation in offshore wind farms takes into account two phases of the support schemes for electricity producers: the first one until 31 December 2022 and the second one from 2023 to 2027 with the statutory possibility of an additional auction in 2028 and further organisation of the auction on the basis of the ordinance of the Council of Ministers. The main difference between the two phases lies in the manner of selecting the entities that will be entitled to benefit from the support scheme. In particular, the first stage of granting support does not deserve for clearly positive evaluation, as the legislator considers that the support will be granted by way of an individual decision of the President of the Energy Regulatory Office for a very limited number of entities, what raise doubts from the point of view of European Union's regulations on state aid, primarily in the light of Article 107 treaty on the functioning of the European Union. Restrictive eligibility criteria for this scheme may result in limiting the initial dynamics of growth of installed capacity in offshore wind farms. The second phase, on the other hand, involves granting support through a competitive auction system, which provides competitions between the producers' bids settled primarily on the basis of the price criterion. In both cases, the support granted to the producers consists of granting them the right to cover the negative balance, which means that the sale of electricity from wind farms will be carried out in the model of a bilateral contract for difference. It can be assessed as a beneficial solution, in the light of the fact that over the last 5 years this model has been successfully used for onshore windfarms and other renewable energy sources in Poland (Urząd Regulacji Energetyki 2020), although it should be stressed that the version proposed for offshore wind farms contains significant differences. It is also worth to remark that the legislative initiative aimed at regulating the issues of offshore wind energy and support schemes into a separate legal act, deserves a clearly positive assessment. There is a strong justification for this, since the implementation of this type of energy projects involves many differentiation from other renewable energy installations. The measure of success of the proposed solutions will be to ensure the most important objectives related to the development of offshore wind farms in Poland, i.e. first of all to prevent the emergence or maintenance of a generation gap in the national power system, as well as the fulfilment by Poland of its climate and energy obligations at the European Union level. If the discussed draft act is adopted it will be an important step towards their implementation.

Bibliography

1. Biuro Bezpieczeństwa Narodowego, *Strategiczna koncepcja bezpieczeństwa morskiego Rzeczypospolitej Polskiej*, Warszawa-Gdynia. 2017.
2. Capacity mechanism working group, *Design a competetive bidding proces, and ensuring competition between new and existing capacity*, 2015 https://ec.europa.eu/competition/sectors/energy/capacity_mechanisms_working_group_april2015.pdf (dostęp: 27.05.2020).
3. Diallo A., Dézsi B., Bartek-Lesi M., Mezősi A., Szajkó G., Kácso E., Szabó L., *Auctions for the Support of Renewable Energy in Poland*, Aures II, Budapest 2018.
4. Długosz, T., *Instrumenty wspierania energetyki niekonwencjonalnej*, [w:] *Publiczne prawo gospodarcze, System Prawa Administracyjnego tom 8B*, R. Hauser, Z. Niewiadomski, A. Wróbel, C.H. Beck, Warszawa. 2018.
5. Drożdż W., Mróz-Malik O., *Morska energetyka wiatrowa jako istotny potencjał rozwoju polskiej gospodarki morskiej*, „Zeszyty Naukowe Uniwersytetu Szczecińskiego. Problemy Transportu i Logistyki" nr 1(2017).
6. Dyrektywa Parlamentu Europejskiego i Rady 2009/28/WE z dnia 23 kwietnia 2009 r. w sprawie promowania stosowania energii ze źródeł odnawialnych zmieniająca i w następstwie uchylająca dyrektywy 2001/77/WE oraz 2003/30/WE (Dz. U. UE. L. z 2009 r. Nr 140, str. 16 z późn. zm.).
7. Dyrektywa Parlamentu Europejskiego i Rady 2014/89/UE z dnia 23 lipca 2014 r. ustanawiająca ramy planowania przestrzennego obszarów morskich (Dz. U. UE. L. z 2014 r. Nr 257, str. 135).
8. Dyrektywa Parlamentu Europejskiego i Rady (UE) 2018/2001 z dnia 11 grudnia 2018 r. w sprawie promowania stosowania energii ze źródeł odnawialnych (Dz. U. UE. L. z 2018 r. Nr 328, str. 82).,
9. Herdzik J., *Zagrożenia dla żeglugi od morskich farm wiatrowych*, „Bezpieczeństwo i Ekologia" nr 10 (2018).
10. Kociubiński J., *Efekt zachęty w kontroli pomocy publicznej w prawie Unii Europejskiej*, „Europejski Przegląd Sądowy" nr 12 (2012).
11. Kurcz B., *Art. 107*, [w:] *Traktat o funkcjonowaniu Unii Europejskiej. Komentarz. Tom II*, K. Kowalik-Bańczyk, M. Szwarc-Kurczer, A. Wróbel, Wolters Kluwer, Warszawa. 2012.
12. Miętkiewicz R., *Morskie farmy wiatrowe a bezpieczeństwo morskie państwa*, „Sprawy międzynardowe" nr 1 (2019).
13. Ministerstwo Energii, *Polityka Energetyczna Polski do 2040 r.,* Warszawa 2019.
14. Ministerstwo Gospodarki, *Krajowy plan działania w zakresie energii ze źródeł odnawialnych*, Warszawa 2010.
15. Ministerstwo Klimatu, *Wiceminister Zyska o potencjale energetyki wiatrowej*, https://www.gov.pl/web/klimat/wiceminister-zyska-o-potencjale-energetyki-wiatrowej (dostęp: 24.05.2020).
16. Muszyński I., *Art. 72 Określenie maksymalnej ilości i wartość wytworzonej energii*, [w:] *Prawo energetyczne. Ustawa o odnawialnych źródłach energii. Ustawa o rynku mocy. Ustawa o inwestycjach w zakresie elektrowni wiatrowych. Komentarz*, C.H. Beck, Warszawa. 2020.

17. Pawełczyk M., *Rozdział II. Prawo Energetyczne, § 6.Regulacja prawna odnawialnych źródeł energii*, [w:] *Prawo gospodarcze publiczne*, A. Powałowski, C.H. Beck, Warszawa. 2017.
18. Polskie Sieci Elektroenergetyczne, *Prognoza pokrycia zapotrzebowania szczytowego na moc w latach 2016 – 2035*, Konstancin-Jeziorna 2016.
19. Projekt ustawy o promowaniu wytwarzania energii elektrycznej w morskich farmach wiatrowych z dnia 23 grudnia 2019 r.
20. Przybylska M., *Prawny charakter aukcji na sprzedaż energii elektrycznej ze źródeł odnawialnych*, C.H. Beck, Warszawa. 2019.
21. Rozporządzenie Ministra Klimatu z dnia 24 kwietnia 2020 r. w sprawie ceny referencyjnej energii elektrycznej z odnawialnych źródeł energii w 2020 r. oraz okresów obowiązujących wytwórców, którzy wygrali aukcje w 2020 r. (Dz. U. poz. 798).
22. Urząd Regulacji Energetyki, *Informacja na temat planów inwestycyjnych w nowe moce wytwórcze w latach 2018 – 2032*, Warszawa 2019.
23. Urząd Regulacji Energetyki, *System aukcyjny ma 5 lat*, 2020 https://www.ure.gov.pl/pl/urzad/informacje-ogolne/aktualnosci/8739,System-aukcyjny-dla-odnawialnych-zrodel-energii-ma-5-lat.html (dostęp: 28.05.2020).
24. Ustawa z dnia 21 marca 1991 r. o obszarach morskich Rzeczypospolitej Polskiej i administracji morskiej (t.j. Dz. U. z 2019 r. poz. 2169 z późn. zm.).
25. Ustawa z dnia 20 lutego 2015 r. o odnawialnych źródłach energii (t.j. Dz. U. z 2020 r. poz. 261 z późn. zm.).,
26. Ustawa z dnia 10 kwietnia 1997 r. - Prawo energetyczne (t.j. Dz. U. z 2020 r. poz. 833 z późn. zm.).
27. Traktat o funkcjonowaniu Unii Europejskiej (Dz. U. z 2004 r. Nr 90, poz. 864/2 z późn. zm.).

Jakub Plebański, Master of Laws, research conducted in the Department of Public Business Law and Environmental Protection at the University of Gdańsk. His scientific interests focus on energy law with particular emphasis on the law of renewable energy sources. Professionally, lawyer supporting investors and renewable energy producers. Enthusiast of offshore wind energy development in Poland.
ORCID: 0000-0002-8125-2888

Public Awareness and Perception of Socio-Economic Characteristic and Biogas in Gwagwalada Town Abuja, Nigeria

Onyekwulu Millicent Chekwube, Ejaro Sunday Peter,
Oguche Christopher Joseph, Diyoke Micheal Chika,
Gwani Samuel, Jibo Magayaki Jamilu

Abstract: Energy is one of the three most fundamental necessities for sustainable development. The consistently expanding interest for energy to meets domestic requirement and the absence of environment friendly alternatives have devastating effect on the environment. Many studies have shown the importance of renewable energy sources that can militates against the negative consequences of using fuels that have an adverse effect on the environment; these include fuel-wood/charcoal which are commonly utilized in a majority of house-holds.

Thus this study was conceived to evaluate the socio economic feature and biogas awareness and perception in Gwagwalada town, Abuja**.** The methodology includes selection and analysis of administered questionnaires to selected study samples via a descriptive statistics method. The study reveals that more than half (60.0%) of the respondents have not heard about the biogas technology, while 40.0% have heard about the technology due to their age, sex, income level and educational experience.

Keywords: biogas, socio economic, sustainable development, Gwagwalada

1.0 INTRODUCTION

The importance of environmental sustainability however defined, as the foundation for social, institutional, and economic well-being, is becoming globally recognized in development approaches. What remains a challenge is the means by which the environmental sustainability can be best achieved with respect to a given geographical location and scenario (Anjaneyulu and Narasimha; 2005). In Nigeria today there are so many practices that are quite unsustainable to the environment. Environmental degradation, such as deforestation, desertification, waste dumping, wetlands destruction, intensive farming, air and water pollution, keep reaching unprecedented proportions. This is particularly evident in Gwagwalada town, Abuja, Nigeria, which is the study area in this work

The role of sustainable forms of energy in National development and GDP growth as well cannot be over-emphasized. Energy assumes a focal role in the national improvement process as a domestic need and central point of development, whose cost straightforwardly influences the cost of different products and enterprises (Amigun and von Blottnitz, 2008). It influences all parts of advancement, for example, social, monetary, political, and environmental, including access to wellbeing, water, agrarian efficiency, mechanical profitability, training, and other essential administrations that improve personal satisfaction. Guaranteeing the arrangement of satisfactory, moderate, proficient and solid top-notch energy administrations with least unfavorable impact on the environment in an economical manner isn't just critical for improvement however urgent for African nations a large portion of which are battling to satisfy present energy needs (Amigun and von Blottnitz, 2008).

The goal of environmental sustainability is to minimize the causes of environmental degradations, to halt and, ideally, reverse the processes they lead to. In the short-term, environmental degradation leads to declining standards of living, the extinctions of large numbers of species, health problems in the human population, conflicts, sometimes violent between groups fighting for a dwindling resource, clean water scarcity and many other major problems.

Biogas technology is an environmentally friendly technology and it entails decomposition of organic materials, called Biomass, in anaerobic environment at a given temperature range by anaerobic bacteria resulting in conversion of the organic matter (biomass) into useable gas, mainly a mixture of methane and carbon dioxide commonly referred to as biogas (Parawira, 2009). This gas is suitable for cooking and lighting. Apart from the benefits of biogas for cooking and lighting, the effluent that comes as slurry is rich with various plant nutrients such as nitrogen, phosphorous, and potash, which are essential for plant growth. The slurry therefore serves as inorganic fertilizer which adds both micro and macro nutrients to the soil (Fisseha, 1991 and Fentaw, 2010). Biogas also improves the indoor and outdoor environments as the use would lead to reduction in the incidents of illness from burning of firewood and dung, and reduction in carbon emission as it would save the trees necessary to sequester more carbon from the atmosphere, abating soil erosion, desertification, loss of soil fertility, avalanches, and landslides (Marry *et al*, 2007).

Many studies state that one of the major causes of deforestation is the collection of firewood for use in rural areas. However, there are other drivers of deforestation which are often overlooked which include access to natural resources. While, it is questionable whether or not firewood collection is a major cause of deforestation, undoubtedly, it is a big contributor to the issue. Depletion of forests is serious issue in many of the rural areas in Nigeria and firewood scarcity in many parts is due to reasons other than collection of firewood, although firewood collection does indeed make the problem worse. This problem along with already depleted soils can lead to a situation where biomass waste that could be helpful in the restoration process is instead used as a domestic fuel. One of the pathways out of this cycle is through the introduction of modern, cleaner and higher quality fuels.

Moreover, the ever-expanding costs of oil based goods all around has made lamp oil, which is the most ordinarily utilized fuel for cooking and lighting unreasonably expensive to many, particularly the country tenants, (Ahmadu, 2009). This, thusly, moves a bigger level of the masses to look for answers for their energy needs from different sources which by and large are adverse to the environment. For instance, there was a 5.5% increase in the dependence on wood fuel for cooking between 2007 and 2008 (NBS, 2009). More so, 79.6% of the households depend on wood fuel for their cooking while kerosene, coal, gas and electricity comes behind from distant 18.5%, 1.1%, 0.6% and 0.2% respectively (NBS, 2009). Poorly managed forests have to shoulder immense burden to meet the increasing demand for energy caused by both the rising population and the lack of development of alternative energy resources.

Notwithstanding meeting the desperate requirement for squander treatment and reusing alternatives to improve a perfect environment, biogas preparing involves the recuperation of significant worth from squandering items (i.e., waste to riches). In this manner, biogas innovation could be a fitting method for squandering the board, energy source, and riches creation. It is therefore that this exploration is attractive to diagram a course for manageable energy creation and usage while a cleaner and more secure environment is upgraded.

LITERATURE REVIEW

1.1 Socio-Economic Evaluation of Biogas Energy Production and Utilization

Several works of scholars on consumer behaviour has succeeded with regards to uncovering the multifaceted nature of elements engaged with the selection procedure with each investigation just adding to the current assemblage of information in the zone by recognizing new factors to be considered in the social capacity (Bekele, 2003). The unpredictability emerges from the area explicit nature of the issue and the decent variety of purchasers' conditions that make it hard to draw some sensible speculation. These distinctions regularly come from the variety in agro-environmental, financial, and institutional elements among nations, areas, towns, or even family units.

The adopter-discernments hypothesis battles that, in actuality, individuals consider numerous qualities in choosing a given innovation and the defense includes choices requiring investigation of an enormous number of unmistakable and immaterial characteristics of the innovation in a choice help environment (Chan et al., 2000). They state that customers, for the most part, have abstract inclinations for qualities of items and that their interest for a specific item is essentially influenced by their view of item ascribed that clients interface legitimately with the advancements and their impression of the specialized attributes could significantly affect its selection rates. The battle that clients will dismiss that innovation was not fit to their workplace and that which may meddle with different exercises considered progressively significant.

Defenders of the adopter-recognitions hypothesis attest that innovation clients are regularly not given sensible open doors for examinations and consultation on elective advancements expected for them. Therefore, client recognitions on different mechanical advancement alternatives are frequently to a great extent neglected which creates doubt in the innovation being advanced; influencing its reception rates. There is a substantial dependence on look into specialists in choosing innovation choices for general society. Given the intricate arrangement of elements impacting reception choices, master based surviving appraisals of innovation selection may prompt unreasonable and one-sided evaluations. This has prompted the acknowledgment that the appropriation procedure isn't just influenced by the mechanical qualities of the innovation, yet in addition, the financial and conduct characteristics of the innovation utilized. This move in the appropriation of standards is confirmed from the ever-expanding writing on factors influencing the selection of new advancements in ongoing decades. (Jones. 2006)

1.2 Biogas as Energy Source

Biogas is used for the most part for cooking and lighting while the slurry gives a decent Well spring of excrement for soil fruitfulness improvement. For operational biogas plants, family units utilize the slurry as manure for their harvests, particularly vegetables and natural products (Karki, 2009). With appropriate area and development of the biogas units, the slurry will uninhibitedly stream downstream to gardens. Slurry happens in the accompanying normal structures: A light and rather strong portion, fundamentally straw or stringy particles which buoy to the highest point of the digester framing a filth, A fluid, watery portion staying in the center layer of the digester, A thick portion underneath which is the genuine slurry or muck, and and heavy solids, fundamentally sand and soil particles, which settle at the base of the digester. On average, farmers with at least four heads of local breed cattle can generate sufficient biogas to meet their daily basic cooking and lighting fuel needs (Ukpabi, 2010).

1.3 Energy Sector in Nigeria and Socio-Economic Development

Energy is a significant element for the improvement procedure of any nation. Energy utilization level is a decent marker of financial improvement level of a nation on the grounds that the energy segment has solid effect on destitution decrease through pay, wellbeing, training, sexual orientation and the environment linkages. In present day times, no nation has figured out how to generously lessen destitution without incredibly expanding the utilization of energy or proficiently using energy or potentially energy administrations. Truth be told, energy influences all parts of advancement – social, monetary and environmental (Amigun et al., 2008).

Thusly, the technique received by a nation in energy use is an essential apparatus in accomplishing monetary improvement since financial thriving and personal satisfaction of a nation are firmly connected to the degree of its per capita energy utilization. In this manner arrangement of sufficient, moderate, productive and solid energy administrations with least impact on the environment is critical. In any case, Nigeria, as in numerous other creating nations, while interest for energy is persistently expanding, it’s flexibly isn't expanding proportionately. Endeavors to expand energy flexibly in an offer to coordinate the expanding energy request must be looked for. Along these lines the utilization of creature and harvest squanders to support energy flexibly in Nigeria turns into a significant and promptly accessible alternative.

In any case, as in many creating nations, there is over-reliance on barely any traditional energy sources involving biomass (kindling, charcoal, crop deposits, and so on), oil based goods and network power as the driver of monetary turn of events. Biomass is the primary wellspring of energy for residential use, trailed by Firewood which is the most widely recognized cooking fuel, especially in rustic territories, and is for the most part utilized in the family units, than charcoal and low rate utilizing power.

1.4. Sources of Energy in Nigeria

Domestic energy can exist as renewable sources, which beings a flow or nature can be used over and over again or as non-renewable resources which are finite as their exploitation can lead to the exhaustion of supplies. Domestic energy used in urban households exists in various forms such as electricity, kerosene, fuel wood, liquefied petroleum gas (LPG), petrol gas and so on (Adegbulugbe, 1979).

A. **Electricity** Early in the 19th century a new form of energy was developed, electricity, the great advantage of electrical energy or electrical power as it is commonly called, is that it can transmitted easily over great distances. As a result, it is the most widely used form of energy in modern civilization (Jame 1996)

Overall hydroelectricity utilization arrived at 816 GW in 2005, comprising of 750 GW of enormous plants and 66 GW of little hydro establishments. Huge hydro limit totalling

10.9 GW was included by China, Brazil and India during the year 2005, yet there was an a lot quicker development (80%) in little hydro plants are by and by found (John 2007).

Hydroelectricity is major source of domestic energy supply and consumption in Nigeria, the hydro potential is estimated at 10,000MW, with a corresponding arrival average energy capacity of about 40,800 GWh (Esan, 1995). The consumption of electricity by different classes of consumers in the country has increased from less than 2000GWh in 1970 to about 8,500 GWh in 1989. In the 1970s, electricity demands double every five years and this increase slowed down in the latter half the 1980-1990 decade due to the downturn in the economy. The president Yardua led administration 2008 and production capacity of 10,000mega watt by the year 2010. Based on the World Bank's forecast growth in electricity paraffin in the United Kingdom and South Africa (not to be confused with the waxy solid also called paraffin wax or just paraffin). The term kerosene is usual in Canada, United States of America, Australia, New Zealand, and Nigeria and so on. Its heating value or heat of combustion is around 18,500 Btv/2b or 43.1 MJ/Kg. It is widely used to power jet-engine air-craft and also commonly used as a heating fuel (John 2007).

B. Kerosene The demand for kerosene (Nigeria National Petroleum Corporation, 1991) in Nigeria has rapidly increased in recent years because of its popularity as an affordable and available form of domestic energy in urban areas. The average consumption has been increased at about 14-16% per annum between 1975 and 1985. However, the growth rate dropped slightly about 12.5% in 1986 and 1990. It is important to note that kerosene is used for dual purposes, thus, apart from its use as domestic for cooking, lighting and so on, it is also used by aviation industry as aviation fuel. This has set a "stain'' on this energy form due to increased number of private airline operators in the country, in line with the privatization programs of the government.

Concurrently, the imbalance in kerosene supply in the country further aggravated by smuggling of the product across the borders to neighbouring countries where kerosene attracts higher prices in foreign currency and also the activities of pipeline vandals who destroy kerosene pipes to expunge kerosene. This usually result to loss of thousand tonnes of kerosene, ecological degradation and loss of life and valuables (Nigeria National Petroleum Corporation, 2005)

According to Osayuki (2005) the total installed capacity of the four Nigeria National Petroluem Corporation (NNPC) refineries in Nigeria is 2,7978,400 metric tones per annum which is not enough to satisfy the current demand of urban households and aviation industry. Presently the price of kerosene is fluctuating on an increasing scale.

C. Liqudifield Petroleum Gas (LPG) As indicated by John(2007), liquified gas (LPG) is a blend of hydrocarbon gases utilized in fuel fabricated during the refining of raw petroleum extricated from oil or gas streams as they rose up out of the ground. Also called cooking gas, liqudified petroluem gas (LPG) is an exceptional household energy source in urban territories as a result of its boss consuming attributes and limit of supplanting chlorofluocarbons as a vaporized charge and a refrigerant to lessen harm to the ozone layer. It assumes a noteworthy job in the household blend of both created and creating nations, assortments of LPG brought and sold incorporate blends that are fundamentally propane, blends that are basically butane and the more typical blends including both propane (60%) and butane (40%), contingent upon the season-in winter more propane and in summer more butane. At ordinary temperatures and weights LPGF will vanish in view of this LPG is provided in pressurized steel chambers are not filled totally, regularly they are filled to somewhere in the range of 80% and 85% of their ability (John, 2007).

The installed capacity of the four NNPC refineries is 306,000kg of LPG per annum is quite enough to satisfy the current demand but because of the instable supply, inadequate distribution network and high cost of LPG appliances (cylinders and cookers), it enjoyed a low patronage in Nigeria (Osamor, 1991). The current demand in the country is about 12,000kg annually and it was projected to be 265,000kg in 2000 (NPC, 1991).

Nigeria's natural gas reserve has been estimated over 3 trillion standard cubic meters, NNPC and joint venture partners shell, Agip, Elf (Total) produces significant amounts of associated gas during the production of crude oil. However, about 75% of the associated gas is flared while the balance is either or treated to pipeline quality sold industries such as power Holding Company of Nigeria (PHCN) and others. The government of some Southern States in the country such as Bayelsa and Rivers are presently harnessing gas resource to power gas turbine engine, which generates and supply electricity.

D. Petrol Nigeria is a member of the Organisation of Petroleum Exporting Countries (OPEC) which she joined in 1971 (Ayodele, 2015) and it is also the sixth largest producer of crude oil in the world (Olajide and Odugenro,1999) Petrol dominated the energy consumption and accounts for 70-80% of the total commercial energy consumed in the country between 19790 and 1980. Petroluem reserves in the country are tenatively estimated at 70 billion barrels in 2001, probably as a result of recent developemnt in off-shore exploraition by the government. (Alepe, 2017). The supply of for domestic consumption takes into account the storage arrangements of oil marketing companies, as incidence of petrol supply within the country and allegation fingers are pointing to oil marketers who are accused of diverting flow of petrol producer to accumulate wealth at the expense of people's life. Another major reason affecting petrol supply in the country is government pricing policy system on petroleum products and also the activities of pipeline vandals who destroy oil pipes for extraction of causing disruption in the supply of petrol in the even of pipeline explosion, valuble and lives are lost due to this act of Mayhem (Osayuki, 2005).

E. Fuel Wood According to Matthew (2000), the chief use of the world's wood is not as building materials or paper but as fuel. Of the 4.4 billion cubic meters of wood harvested in 1996, close to 1.9 billion cubic meter are burned for cooking or not provide heat, or are used to make charcoal for latter burning (Food and Agriculture Organisation 1999).

However, in many developing countries of the world dependence on fuel wood is higher than developed countries. In countries like Nepal in Asia, and Uganda, Tanzania and Nigeria in Sub-Saharan Africa, fuel wood provides 80% or more of the total energy requirement. While in industrial countries, fuel wood contributes only about 3% of total energy supply. There are exceptions in Sweden and Fineland which accounts for more 16% of the total fuel wood supply in some central east European countries(FAO, 1999).

Fuel wood energy is obtained from trees, and Nigeria is blessed with a total land area of about 960,000km^2. An estimated 369,000 km^2 (about 40%) has been classified as forestland with high forest zone of about 133,000km^2 and savanna woodland of about 227,000km^2 (FAO, 1979).

Majority of urban households in developing countries opt for fuel wood as a domestic source of energy for cooking, heating, boiling, drying and so on probably because it is the most efficient, available and affordable source of domestic energy. Some residents insist that no meal is more delicious than those prepared with wood (Osayuki, 2005). About 70% of the total domestic energy consumed in developing countris is of wood origin and over 80% of Nigeria populace uses fuel wood as a traditional energy source. Fuel wood extraction is a source of income generation and it also offers employment opportunity to many jobless individuals in the country. (Olajide et al, 1999b).

However, the excessive consumption of fuel wood and other traditional fuels is carried out at great cost to the individual, like community, the fuels is carried out at great cost to the individual, like community, the economy and environment as a whole. This is as result of reckless and uncontrolled exploration of fuel wood, which results to environmental degradation and up to currnet concern ‶global warming″. The individual is exposed to health hazards during the burning of fuel wood by releasing carbon dioxide, which is quite harmful to human health especially the utilization of fuel wood is not economically efficent because of its high cost presently and its effect on deforestation is economically destructive (Hosier, 2011).

The projections of global fuel wood consumption in 2000 range from 1.5 billion m^3 (a decrease of 16% from 1998 levels) to 4.25 billion m^3 (an increase of 136%) (Brooks et al, 1996). While the yearly utilization of fuel wood in the nation is assessed to run between 51-88 million m3 of which 80% is devoured as fuel wood to suggest a high accessibility and fuel wood utilization was anticipated to be 34.83 million m3 in the nation as at the year 2000 (Osayuki, 2005).

F. Charcoal Also known as ‵local gas″ profoundly among producers of charcoal, it is a domestic energy source derived when wood is heated to about 25^{O}C (480^{O}F) thereby evaporating the moisture and volatile materials, leaving carbon inert materials in the form of charcoal. (Ayodele, 2015). Charcoal burns a luminous flame which is widely used as household fuel for cooking with charcoal stoves, ironing with local pressing irons and so on. Charcoal is well patronized by urban dwellers because it produces a blue somkeless flame and also it is convenient to transport when compared with fuel wood. Its potentials are quite high because of vast forest cover in the country. Specially charcoal is made from heatin selected trees species such as shea butter and so on. The business of production and sale of charcoal is quite lucrative as men and women engage in the processing, packing and selling of charcoal to earn a living. However, the consequences of charcoal exploitation include air pollution, deforestation, densification and so on can be obtained directly and indirectly to provide heat, lighting, and power from various sources as: hydropower, solar energy, geothermal power, wind power, nuclear energy, mechanical energy.

Energy Poverty in Nigeria

Indeed, even in Nigerian homes with electricity, the quality of service provided is often intermittent while growing increasingly very expensive, despite the fact that there is roughly three hours per day of power (electricity). There was price increase in electricity tarif at a time when 92.4 percent of Nigerians live on less than $2 per day, and 70.8 percent live on less than one dollar per day. Andrew (2015)

The problem of energy poverty is not only to Nigeria only but to other developing countries of the world. According to the International Energy Agency 2017, “over 1.3 billion people are without access to electricity and 2.6 billion are without clean cooking facilities (charcoal and other forest products). More than 95% of these people are in sub-Saharan Africa or developing Asia and 84% are in rural areas.” Though the problem is not unique to Nigeria, it does bring to light the global inequality behind the phenomenon of energy poverty despite Nigeria’s status as a major energy exporter. Andrew (2015) It is seemingly paradoxical for a nation which began exporting large amounts of liquid petroleum gas through Chevron in 1997 to have a per capita liquid petroleum gas usage rate of 0.4 kilograms per second, one of the lowest in the region.

Fig 1: Energy Poverty in Nigeria

Sources: New York Times Photo: MAY 21, (2015)

Addressing energy poverty is a key point in the fight against global poverty. Greater access to alternative energy sources will reduce unnecessary deaths, such as the 95,300 Nigerian deaths which occur annually from smoke created by the use of solid biomass fuels. It will enhance the financial capabilities of those nations currently struggling to provide power to businesses. This, in turn, will expand the global community of consumers. Regardless, the importance of treating energy exporters as nations, and not simply as trade partners, remains a primary challenge moving forward in the fight against global inequality.

Empirical studies on awareness and perception of biogas technology alongside socio economic factors have yielded ambiguous results. While some studies found a positive relationship between biogas technology alongside socio economic factors (Arduin, Nascia and Zanfei, 2010; BenYoussef, Hadhri and M’Henni, 2010; Gallego et al., 2011), other studies have shown an insignificant or a negative correlation between them (Bayo-Moriones and Lera-

Lopez, 2007; Bocquet and Brossard, 2007). Furthermore, Hollestein (2014) maintains that the relationship is non-linear by asserting that income level has a positive impact on the adoption and use of biogas technology. Despite these studies, no logical conclusion has been reached as to the inherent factors that have motivated the use of a well awareness on biogas in the Nigerian. The findings of most research on biogas technology usage and its application have not identified the major factors that can be said to influence the adoption of alternative to biogas practice in Nigeria and particularly the study area, Gwagwalada. This gap in the literature is therefore the basis for this study.

The factors utilised for investigation were extracted from the literature review. The need to identify the household primary cooking fuel were adopted and modified from Sawyer and Crowston (2014). Determine the domestic energy expenses and income level were taken from Oladapo (2011). View respondent awareness and perception of biogas technology were modified and sourced from Asgarkhani and Young (2010) and Spanos, Prastacos and Poulymenakou (2002).

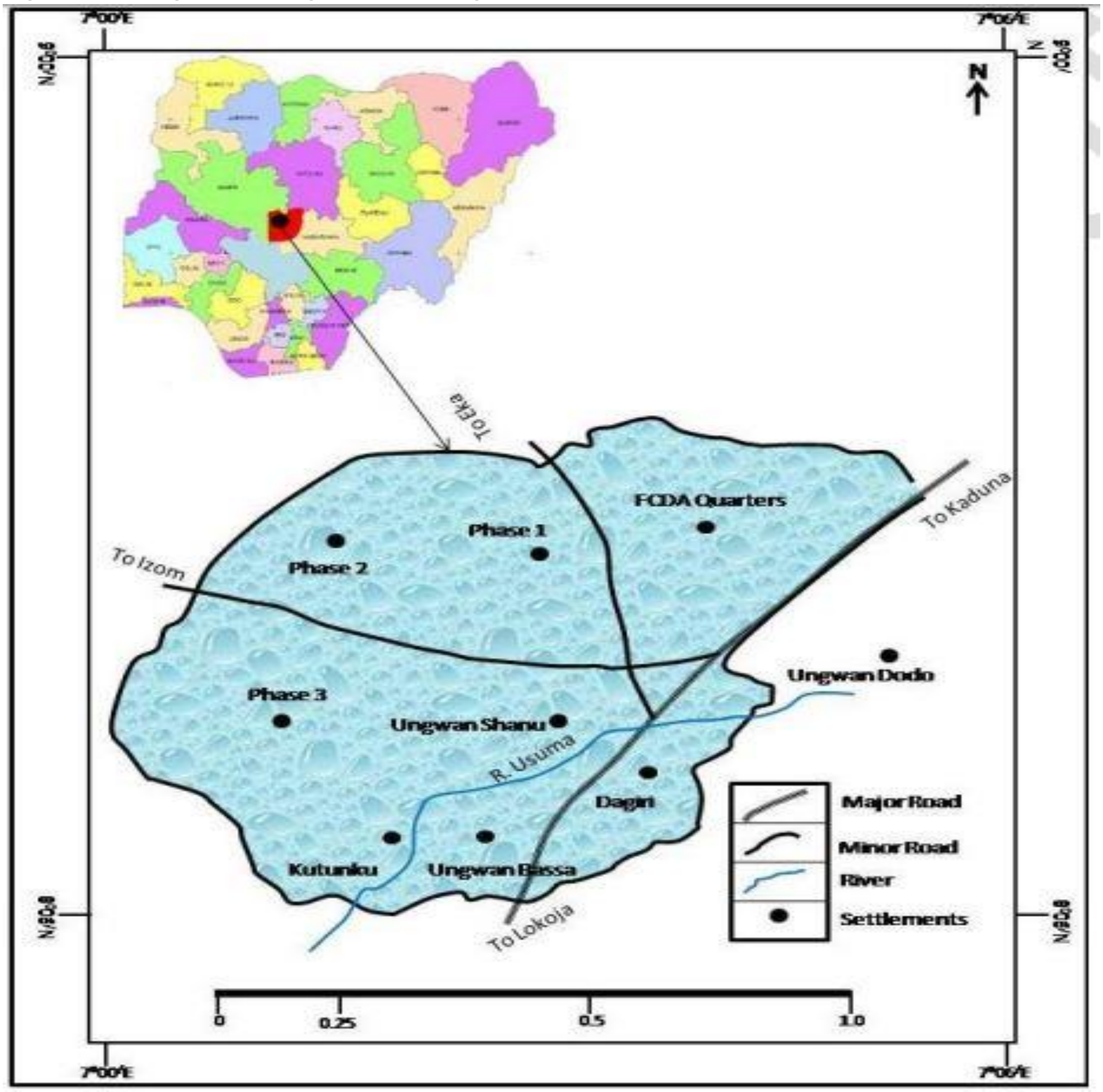
2.0 STUDY LOCATION

Gwagwalada town is situated about 54Kilometers away from the Federal Capital City and it is midway situated inside the FCT. It is situated on a trunk A2 Street along Kaduna-Lokoja Street and it is around sixty (60) kilometers west of the FCT. The Gwagwalada Urban, region is situated between scopes 8006’00”N to 9000’00”N and 7 000’00”E to 7008’00”Figure 1). It is limited by Kuje Area Council toward the East, Abaji Area Council toward the West, Kwali territory Council toward the South and Abuja Municipal toward the North East and Suleja Local Government in Niger State toward the North (Gwagwalada Master Plan, 1979). The investigation region has an all-out landmass of around 6,500 hectares (65km2) and with the fast pace of urbanization, formative procedures are presently occurring even outside the limit of the assigned urban region.

The population of Gwagwalada has been fast increasing as a result of natural (high fertility) reduction in death rate, and mass influx of people into the area, especially with its status as a satellite town in the FCT. Thus, because of the last movement of the seat of Federal Capital from Lagos to Abuja, its official populace figure of Gwagwalada Area Council is 157,770 of which 34216 is the number of inhabitants in Gwagwalada town (NPC, 2006). Gwagwalada is the second large city in Abuja with a total landmass of 65 square kilometres. It is located at the centre of a very fertile agricultural area with abundant clay deposit to its north-east and south-west (Mundi 2000 and Balogun, 2001).

Gwagwalada records the highest temperature during the dry season’s months, which are generally cloudless. The maximum temperature occurs in the month of March with amount varying from 37^{o}C in the south west to 30 ^{o}C in the North-East. This is also the period of high diurnal ranges of temperature. By July to August diurnal range rarely exceed 70 ^{o}C according (Adakayi, 2000). A number of local soils have been identified within the study area such as alluvial soils. These soils are commonly found in the valleys of the main rivers and streams all over of the FCT. The soils are somewhat narrow in coverage with rivers and streams deeply entrenched in such areas (Balogun, 2000).

Fig 2. Map of Nigeria Showing FCT and Gwagwalada Town.



3.0 MATERIALS AND METHODS

The method adopted to carry out this research is discussed under the following sub headings; data types and mode of collection, sampling technique, questionnaire administration, data analysis and presentation.

3.1 Method of Data Collection

Valuable primary data regarding the selected case was gathered from key informants; National Biotechnology Development in the department of Environmental Biotechnology, Energy Vendors like the gas sellers, Kerosene hawkers, firewood sellers and the end users residents. Semi structured guidance questionnaire were developed to conduct interview which was beneficial to get information relevant to the study. Besides the interview, field visits were paid to various energy retail outlets. It helps the Researcher to observe the actual situation and to know people's perception about biogas production.

To gather information necessary for this research, informal research was conducted to obtain relevant information from literature. The study took advantage of reports articles from notable International and local journals, internet, published and unpublished thesis and dissertations.

3.2 Sampling Technique

Gwagwalada town is made up of several districts. Prominent among them is a planned settlements which is sub divided into phases; phase one, phase one low cost, phase 2 and Phase 3. Other lay outs include; Kontagora Estate. Surrounding settlements that sprawled out around these districts are Old kutunku, New Kuntunku, Passo, Angwan Dodo among others. Five out of these settlements were selected purposively considering their similarity and differences in structure and economic composition of the residents. Within the districts, Phase 1 low cost and Kontagora estates were selected, while within the sprawling settlements; Angwan Dodo, Passo and old Kuntuku were selected.

Different sampling technique methods were deployed depending on the unit of analysis and type of information required. Purposive sampling, a procedure which involves intentional selection was used at various stages of the research. This method was adopted with mainly the community leaders, fire wood vendors, kerosene and gas retail outlets, who were in a position to give information on specific areas of interest.

To sample the population in the Sprawling settlements, it was very difficult to be systematic due to the unplanned nature of the area. The houses are not arranged in any particular pattern and there is no existing map of the area. As a result of this some clusters were identified and a sketch map of each cluster was developed and 50 households were randomly selected each from Passo, Angwar Dodo and Old Kutunku.

In Phase 1 Low cost the house lay in rows and consists of mixed dwelling units of 1, 2 and 3 bedrooms detached bungalows. It is clustered on street basis. The settlement has a total of 28 streets with each street having about 14 houses. The questionnaires were administered on street by street basis a total of 40 Questionnaire were systematically administered within the Phase 1 Low Cost Housing. The same Procedure was also used to select 25 respondents in Kontagora Estate. Altogether a total of 200 respondents were selected for interview. See table 1.

Table 1. Sample Households

Gwagwalada District	**Number Of Respondents Selected**
Kontagora	20
Phase I Low-Cost	40
Kutunku	50
Passo	50
Angwan Dodo	40
Total	200

Source: Author's fieldwork 2014

A pre-test was conducted and the survey questionnaire was subsequently refined. The researcher hired some field assistants who helped the researcher in the questionnaire distribution. Each questionnaire took an average of 30 minutes to implement. The field assistants were instructed to interview the mother or wife in the household, if available, otherwise, the father or husband or any adult who was available. The questionnaire collected information on the following: socioeconomic characteristics of the respondents, households' level of awareness and response to energy crisis, household level of energy consumption, and household awareness of biogas technology. A total of 215 questionnaire were distributed, however only 200 (86.6%) were analysed, the rest were either not returned or not properly filled.

4.0 RESULTS AND DISCUSSIONS

Below is the findings of the study and discussions of the results of people's socio economic feature and biogas awareness and perception

4.1 Social and Economic Characteristics of Respondent

The social and economic characteristic of the respondents includes gender, age, educational, household size distribution, main economic activities and average income of the respondents.

Table: 4.1.1 Gender Distribution of Respondent

Gender	Respondents	Percentage (%)
MALE	84	42%
FEMALE	116	58%
TOTAL	200	100%

Source: Field Survey (2014)

The table above indicate that the majority of (58%) of the households in the study area are female as compared to (45%) male. This has an implication on household decision making system, the decision on whether the household adopts biogas technology or not. This indicates that the energy source's environmental impact would have more effect on the women and invariably the children.

Table: 4.1.2 Age distribution of the Respondents.

AGE DISTRIBUTION(YEAR)	RESPONDENT	PERCENTAGE
20-30	68	34%
31-40	74	37%
41-50	44	22%
50-60	12	6%
Above 60	2	1%
Total	200	100%

Source: Field Survey (2014)

The result from the above table indicate that a majority of respondents were in the economically active age, that is 20-40years which relates to peak level of awareness of modern innovations. It implies that market development for biogas production and utilization can rapidly be achieved.

Table: 4.1.3 Educational Qualifications of Respondents

EDUCATIONAL QUALIFICATION	RESPONDENT	PERCENTAGE
PRIMARY	34	17%

SECONDARY	70	35%
TERTIARY	86	43%
OTHERS	10	5%
TOATL	200	100%

Source: Field Survey (2014)

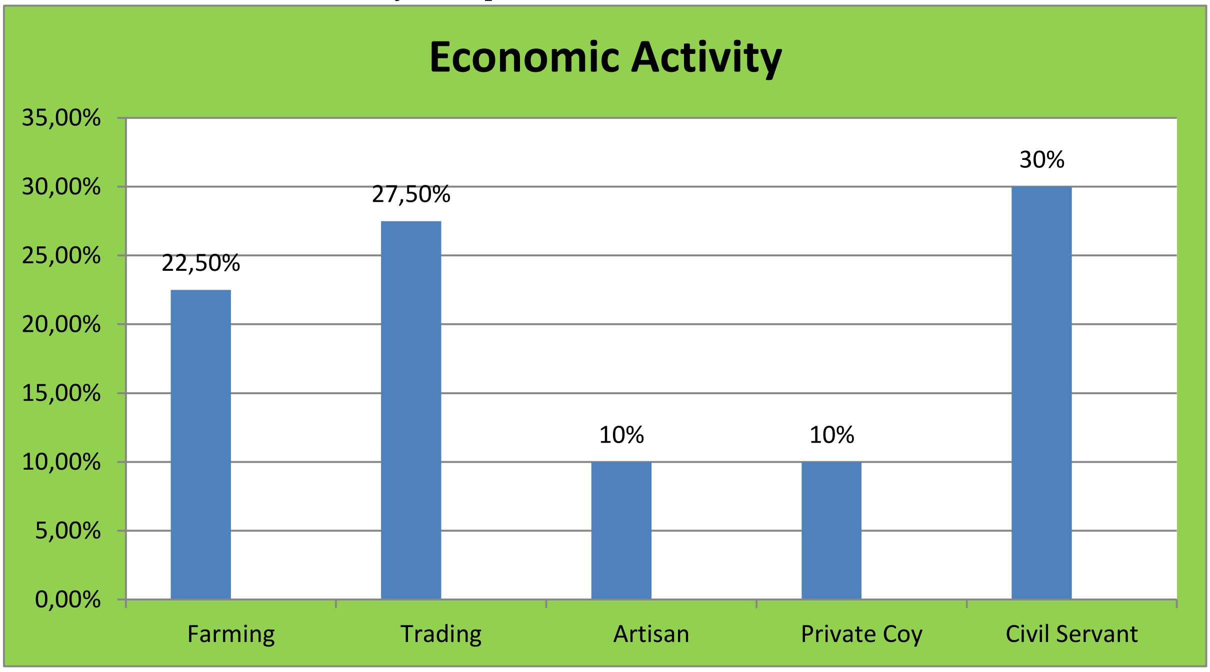
The table above indicates that a large part of the sample population can at least read and write, meaning that the individuals are trainable as far as biogas technology knowledge is concern.

Table 4.1.4: Household Size Distribution of Respondent

Household Size Distribution	Respondent	Percentage
1-5	132	66%
6- 10	64	32%
11- 15	2	1%
Above 15	2	1%
Total	200	100

Sources: Field Survey (2014)

Table 4.1.5 Main Economic Activity of Respondents



Sources: Field Survey (2014)

The major economic activity in the study area is Wage Employment as indicated by the result in the above bar chart. This indicates that besides deforestation, most of the waste dumped in the environment are generated at home as domestic organic waste necessary for production of biogas as alternative, accessible and cheaper source of domestic energy.

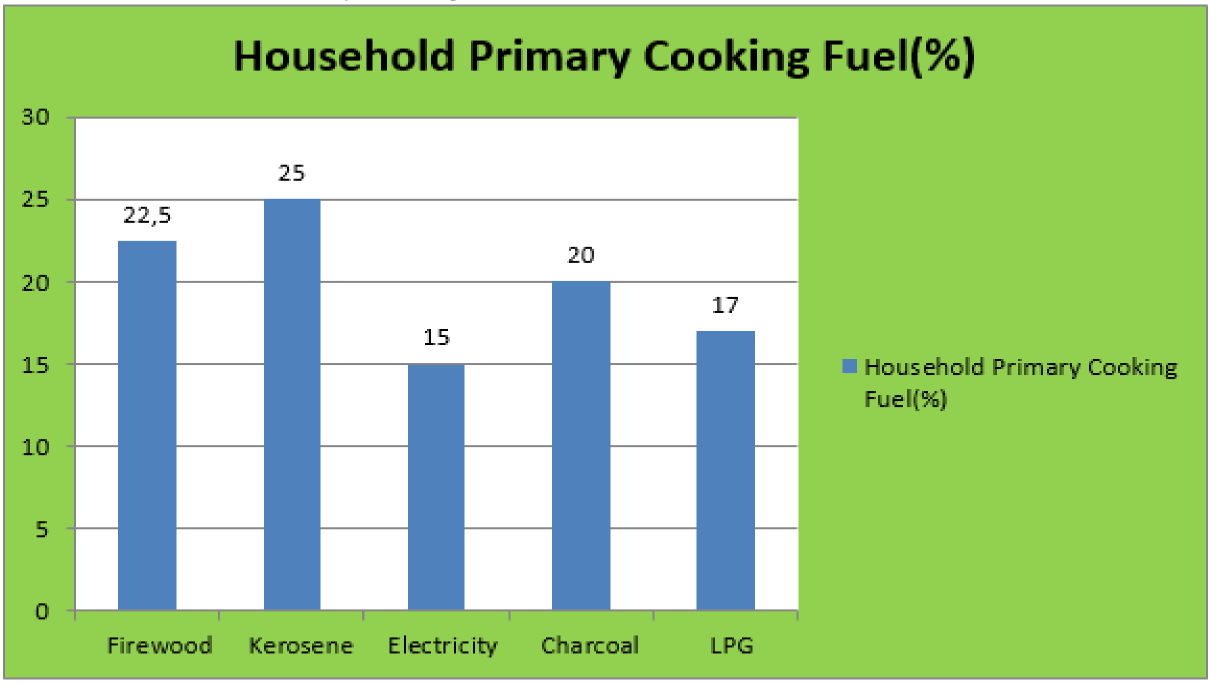
Table: 4.1.6 Average Incomes of Respondents

Income of Respondent(₦)	Frequency	Percentage
5,000- 20,000	82	41%
21,000-50,000	80	40%
51,000-80,000	12	6%
81,000-100,000	12	6%
Above 100,000	14	7%
Total	200	100%

Sources: Field Survey (2014)

The study tends to confirm that the majority are generally low and near middle income earners. This however would have an economic implication on the choice of domestic energy utilization and expected affordability of biogas.

Table: 4.2: Household Primary Cooking Fuel



Sources: Field Survey (2014)

The above indicates the main energy sources in the study area. The study reveals that majority of the respondents prefer kerosene as their fuel. Fuel wood (Firewood and Charcoal) is closely used as alternative. Considering the two sources, it is obvious that 42.5% of the domestic energy come from the forest. This implies that there is high degree of deforestation, carbon emission arising from burning the fuel wood and consequently a heightened environmental pollution. The reasons cited for cooking fuel preference are affordability, availability and accessibility.

Table 4.3: Main Energy Source and Income Level of Respondents compared

Source of Domestic Fuel	Respondents	Income Level	Respondents
Firewood	45	5,000- 20,000	82
Kerosene	50	21,000-50,000	80
Electricity	30	51,000-80,000	12
Charcoal	40	81,000-100,000	12
LPG	35	Above 100,000	14
TOTAL	200		200

Source: Field Survey (2014)

From the above table, fuel wood accounts for the highest proportion of domestic energy consumption in the study area. It is obvious that this domestic fuel is predominant among low income level earners. The table also indicate that several households also make use of Electricity for heating and lighting along with other domestic energy sources for cooking. Gas (LPG) is used by those of higher income level. High cost of gas and poor awareness and epileptic electricity supply were found to be deterring factor for the low use of these energy sources in the study area. Thus gas like Biogas which would be produced from thereby waste dump sites is deemed to be affordable and accessible and can be the reliable alternative energy source for environmental sustainability.

Table: 4.3.1: Household Monthly Spending on Firewood and Charcoal of Respondent

Estimated Expenditure (Naira)	Angwar Dodo	Kutunku	Passo	Kotagora	Low Cost	Total
Firewood	**No.50**	**No.50**	**No.50**	**No.20**	**No.30**	**200**
Below 2000	[24] 48.0	[24] 48.0	[22] 44.0	[5] 25.0	[13] 43.3	[88] 45.0
2000-3000	[16] 32.0	[18] 36.0	[15] 30.0	[7] 35.0	[9] 30.0	[65] 32.5
Above3000	[10] 20.0	[8] 16.0	[13] 26.0	[8] 40.0	[8] 26.7	[47] 23.5
Total	**50**	**50**	**50**	**20**	**30**	**200**
Charcoal						
Below 2000	[20] 40.0	[17] 35.0	[14] 28.0	**[6] 30.0**	[14] 46.7	[73] 36.5
2000-3000	[23] 46.0	[23] 46.0	[19] 38.0	[8] 40.0	[6] 20.0	[72] 36.0
Above 3000	**[7] 14.0**	**[10] 20.0**	**[13] 26.0**	**[6] 30.0**	**[10] 33.3**	**[55] 27.5**
Total	**50**	**50**	**50**	**20**	**30**	**200**

Source: Field Survey (2014)

The table depicts that use of fuel wood and charcoal has no bound in the study area with respect to income level. Residents of all income levels make use of these forest products as either a major source of energy or supplementary source to support large cooking in social functions and those who operate restaurants and canteens. Results in the table reveal that 45.5% spend below N2, 000.00 per month, while 36.5% spend the corresponding amount on charcoal. Those that spend above N3000.00 are relatively low.

Table 4.4.: Respondents Awareness and Perception of Biogas Technology in the Study Area

Respondents	Total	Awareness	
		Aware	Not Aware
Angwar Dodo	40	10	30
Kutunku	50	15	35
Passo	50	10	45
Kotagora Estate	20	15	5
Phase 1Low Cost	40	30	5
Total	200	80	120

Source: Field Survey (2014)

Findings in Table 4.3 show that majority 60.0% of the respondents have not heard about the biogas technology, while 40.0% have heard about the technology.

In summarizes the relationship between household characteristics and Awareness of biogas technology. These characteristics include age of respondent, education level of household head, household size and sex, can be said that the residential area is not of very much significance in the study because all settlements now harbor all categories of income level and occupational structure; rather, it was the level of education and income level.

Sex of Respondent and Awareness

Findings in table 5.1 indicate that the majority of the male respondent **(57)** comprising of 28.5% have heard about biogas technology before and also Majority of the female respondents (66) 33.0% have not heard about the Technology before the time of this research. This indicates that the technology has not received much publicity in the country.

Age of Respondent and Awareness

Findings in Table 4.4.1 also indicate that younger respondents **(51)** comprising 22.5% of respondents aged between **20 to 40** years old were more likely to have heard about biogas technology compared to older respondents aged above 40 years. The plausible explanation of this can be that younger people especially at tertiary level of education school age are more inquisitive to know about new innovations. They have more access to information through a variety of medium than the older ones especially in developing countries where economic hardship is prevalent.

Education Level and Biogas Awareness

The relationship between education and biogas awareness as indicated in the above table show that the majority of the respondents (47) 23.5% who have heard about biogas were those with tertiary education compared to those with secondary or other forms of education. This can be explained by the nature of education itself. Education opens an individual's mind to wide range of information and exposure. Comparatively, people who attained secondary and college education the Study area were more likely to be in wage employment like teaching, area council administration, private sector, police officers among others. People belonging to this category, firstly, most of them live in public or hired houses hence have no permanent premises, secondly being public or civil servants they are liable to be transferred to other work places, hence they are unlikely to invest in biogas technology which is a permanent and non-transferable structure as compared to those who own permanent premises.

Household Size and Biogas Awareness

The relationship between household size and biogas awareness is that households with many members are more concern about high cost of energy and are worried about an alternative also households with large size of family are more stricken with poverty and are associated with less education. It was expected they will not receive information more readily than those with smaller size of family.

Main Economic Activity and Biogas Awareness

The table indicate that a majority of those that are aware of biogas technology were those engaged in civil service compared to those engaged in farming and trading. This can be explained by the fact that biogas production in Nigeria is still at the policy level therefore more people in government employment are informed of the biogas plants at the pilot stage.

5.0 CONCLUSION AND RECOMMENDATIONS

This study should be embraced and adjusted and put into utilization as a team with organizations that are associated with advancing indigenous designing tasks that can tackle present issues. It had been seen that degree of salary, level of instruction, and age assume a critical job in the decision of energy used for cooking and other local purposes. Without the open attention to biogas innovation, its advantages, and entanglements, there will be no adequate premise to scatter biogas innovation at the grassroots level. Simultaneously, mindfulness inside the administration is fundamental since effects and parts of biogas innovation concern such a significant number of various legislative foundations (for example horticulture, environment, energy, financial aspects), it is important to recognize and remember all dependable government offices for the spread and mindfulness raising procedure.

The following recommendations are made for actions to be taken in order to promote and raise levels of Public Awareness and Perception of Socio-Economic Characteristic and Biogas in Gwagwalada Town Abuja, Nigeria, Enlightenment campaigns using media, for example, radio, TV, and handbills through indigenous dialects should be urged for individuals to get mindful about the reasonableness, wellbeing, and moderateness of biogas innovation advancements. The Federal government should encourage the use of National Orientation Agency (NOA) at the Area councils. Political leaders through policy reviews can promote the technology through media discourse and through incorporating the renewable energy policy in Government development plans. District councils should hire extension workers to educate community member on biogas efficiency. National Biotechnology Development Agency (NABDA), under Ministry of Science and Technology, will play coordination role to ensure sustainability of the environment and the implementation of the set strategies for the development of biogas sector in the country.

Bibliography

1. Adakayi, P.E. (2000): climate (Ch.2) in P.D. Dawam (ed) The Geography of Federal Capital Territory, Jos, Nigeria P.P. 9-22.
2. Andrew Michaels (2015) CAI, UNICEF EIA, International Association for Energy Economics, Journal of Public Administration and Policy Research 3.2
3. Ahmadu T. O. (2009). Comparative Performance of Cow Dung and Chicken Droppings for Biogas production, Msc Thesis submitted to the Department of Mechanical Engineering, Ahmadu Bello University Zaria
4. Alepe, S.M.‶ (2017) The Future of Oil and Gas in Nigeria. Paper for the 10th N.I.J. Oil Seminary by ELF Nigeria limited, Lagos, Nigeria.
5. Amigun B., Von Blottnitz H. (2008). Investigation of scale economies for African biogas installations. Energy Conversion and Management, 48:3090- 3094.

6. Anjaneyulu .Y. and Narasimha .R.P (2005) Introduction to environmental Science. B.S publications Hyderabad, An Economic Analysis of the Impact of the Withdrawal of Petroleum Subsidies on the Demand for Biomass in Nigeria: Being a Paper prepares for Staff Research Seminar, on Development of Economics, University of Nigeria, Nsukka
7. Ayodele, A.S. (2015) Energy Consumption Nigeria Institute of Social and Economic Research, (N.I.S.E.R.) Ibadan.
8. Balogun, O. (2001), The Federal Capital Territory of Nigeria: A Geography ofIt's Development, Ibadan University Press; University of Abuja.
9. Chup, C.D. (2000): Landform (Ch.5) in P.D. Dawam (Ed). The Geography of Federal Capital Territory, Jos.
10. Cotthem, W. V. (2010). A dynamic approach to desertification challenge in Northern Nigeria; biogas. Retrieved on December 13, 2010, from http://anaerobicdigestion.blogspot.com/share
11. F.A.O. (2001): Forest (1995): Mini and Macro Hydro Schemes in Power Production in Global Climate Change: Impact on Energy Development P.P/ 341-365. Development in Nigeria. F.U. SF/NIR/J46. Technical Report 3, UN DPI FAO, Rome.
12. F.A.O. (2009): Fuel Wood Collection and Deforestation in Developing Countries. Resource Assessment Journal, P.P. 10-15.
13. F.C.D.A (2013): Gwagwalada Master Plan Abuja F.C.D.A Federal Republic of Nigeria, (1991): Population Census (Provisional result)
14. Fentaw Ejigu and Hailu Araya, (2010). Activity report for 2010 on Building awareness on the value of bio-slurry and its use as organic fertilizer, set up a system to record, analyze and report the impact of bio-slurry on crop yield and making cross visits, Institute For Sustainable Development(ISD)and National Biogas Program Ethiopia(NBPE).
15. Fisseha Tegegn, (1991). Biogas in Ethiopia, Ethiopian Energy Authority Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2015.04.026
16. Gwagwalada Master Plan Abuja F.C.D.A. Federal Republic of Nigeria, (1991): Population Census (Provisional result).
17. Iwayemi A. (2008). Nigeria's Dual Energy problems: Policy Issues and challenges Being a paper presented at the 31st International Association for Energy Economics International Conference, Istanbul, Turkey.
18. Mary P. S., Renwick. H, (2007).An African Initiative a Cost-Benefit Analysis Of National And Regional Integrated Biogas and Sanitation Programs in Sub-Saharan Africa, Draft Final Report Prepared For The Dutch Ministry of Foreign Affairs ,Biogas For Better Life.
19. Matthew E. (2000): The Need for an Alternative Source of Energy: Journal Of the Abuja Geographer: University of Abuja, P.P. 10. Vol. 1.No.1.
20. Mundi, R. (1996): Population (Ch.2) in P.D Dawam (Ed). The geography Of Federal Capital Territory Jos Nigeria. National Population Commission 2006; www.population.gov.ng
21. NNPC (2000): NNPC Botanization Programme I: presented at the national Workshop on safety precaution in the Handling and Liquefied Petroleum Gas (LPG)
22. NNPC (2005): Statistical bulletin on Facts and Figure of Oil production in Nigeria.
23. Olajide, J.O. and Odugenro P.C. (1999): Urban Household Energy and Food preparation in Nigeria in Journal of Fuel Option for Household Energy issue 44: Ibadan.

24. OPEC. (2008): Facts and Figures: A Geographical Analysis of Wood Energy up to 1992: Vienna
25. Osayuki, O.L. (2005): Public Attitude Towards Alternative of Fuel Wood: A Case study of Paikon Kore. Geography Developement University of Abuja.
26. Parawira, W. and Mahandete, A.M. (2009) Biogas Technology Research in Selected Sub-Sahara African. African Journal of Biotechnology 8 (2):116-125.
27. Ukpabi, C. (2010). Biogas for Better Life, an African Initiative. http://biogasafrica.org/index.php?option=com_docman&Itemid=16=en(17/5/2011). UMN (1985) Tunnel Plant. Biogas. In: *Challenges and Experience from Nepal* Vol. 1.pp4.1-4.15
28. John N, (2007): World Energy Resources and Consumptions.Newsletter of Energy Digest.
29. Yakubu, I. B. (2010).Issues in land management; masters in Environmental Management lecture notes, Department of Geography, Faculty of Social and Management Sciences, Bayero University Kano.

Appendix 1

QUESTIONNAIRE

SECTION A

Personal Data

Please tick right as appropriate to your answer in the box provided:

1. Date of interview ………………………...…………………………………………...
2. Name of the respondent …………………….……………………………………...
3. Settlement ……………………………………………………………………………
4. Sex: Male ( ) Female ( )
5. Marital Status: Single ( ) Married ( )
6. What is your highest level of education?
   (i) Never attended formal education ( )
   (ii) Primary School ( )
   (iii) Secondary School ( )
   (iv) Tertiary Education ( )
   (v) Others ( )
7. Main occupation of the head of household;
   (i) Farming ( )
   (ii) Trading.( )
   (iii) Civil Service ( )
   (iv) Others (specify) ( )
8. Household Income: What is your average income per year? (₦........)

SECTION B

Awareness, Attitude and promotion of adoption of biogas technology

A. Awareness

21. Have you ever heard about the biogas technology?
    (i) Yes ( )
    (ii) No( )
22. Have you adopted biogas technology?

(i) Yes ( )
(ii) No ( )

23. Who gave you information about biogas technology for the first time?
(i) Researcher ( )
(ii) Extension officers ( )
(iii) Politician ( )
(iv) Neighbor, Relative, friend who adopted BT ( )
(v) National Biotechnology Development Agency staff ( )
(vi) Others (Specify) ……………………………………………………………..

24. If you have not adopted biogas technology, give reasons;
(i) Do not see the benefit of biogas technology ( )
(ii) Shortage of household labour ( )
(iii) Plenty of fuel wood in the area am living ( )
(iv) High Technology costs ( )
(v) Not aware of the technology ( )
(vi) I find it not appropriate ( )
(vii) Others (specify)…………………………………………………………………

Onyekwulu Millicent Chekwube, M.Sc., works in the National Biotechnology Development Agency in Abuja, Nigeria. M.Sc. in geography (Environmental Resource Planning) at the University of Abuja, Abuja Nigeria Faculty of Social Sciences. Her interests include the energy sector, biodiversity and environmental management issues.
ORCID: 0000-0002-0980-3905

Ejaro Sunday Peter, M.Sc, PhD, works in the Department of Geography and Environmental Management at the University of Abuja, Abuja Nigeria. M.Sc, PhD in geography (Environmental Resource Planning), Faculty of Social Sciences. His interests include GIS, land use, land cover and environmental resources management issues.
ORCID: 0000-000-2223-2772

Oguche Christopher Joseph, M.Sc., a PhD Student of geography and environmental management at the University of Abuja, Abuja Nigeria, Faculty of Social Sciences. His interests include environmental resources management, transportation, human settlements and energy sector issues.
ORCID: 0000-0003-2032-7943.

Diyoke Micheal Chika, M.A., works in the Department of Sociology at the Nnamdi Azikiwe University Awka, Nigeria, Faculty of Social Sciences. PhD Student of Sociology Department at the University of Abuja, Abuja Nigeria. His interests include criminology, prison reform and energy sector issues.
ORCID: 0000-0003-4158-5570

Gwani Samuel, M.Sc., a PhD Student of geography and environmental management at the Nasarawa State University, Keffi, Nasarawa State, Nigeria, Faculty of Social Sciences. His interests include environmental resources management, land administration, land policy and energy sector issues.
ORCID: 0000-0003-0585-7540

Jibo Magayaki Jamilu, M.Sc., works at the Nigeria Social Insurance Trust Fund. A PhD student in the Department of Geography and Environmental Management at the University of Abuja, Abuja Nigeria, Faculty of Social Sciences. His interests include environmental resources management, agricultural policy, afforestation ethic, land policy and energy sector issues.
ORCID: 0000-0002-3567-9397

The Renewable Energy in Baltic States versus Russian Federation Political Interests

Grażyna Mórawska

Abstract: The following article treats about the problem of renewable energy sources in Baltic states in the context of Russian Federation European interests. To be more precise, it raises the topic of energy domination policy, which is an integral part of Russian geostrategy. Author makes an attempt to take a look at the influence of renewable energy sources on the Russian-Baltic affairs, whereas Baltic states are importers of widely understood energy – electricity, natural gas, petroleum etc.

This article has its theoretical basis on the complex interdependence theory by Robert Keohane and Joseph Nye. Main hypothesis to verify states that the intensification of renewable energy exploitation brings a positive impact on the Baltic states position in negotiations with Russia. The interdependence model of those countries to Kremlin should move from "vulnerability" towards "sensitivity", which is relative better.

Main point of this article is denying the geopolitical determinism and a simplified, static view on international affairs, which is actually popular in Polish public debate. Poles have great faith in the theses of classic realists, just like Hans Morgenthau or Kenneth Waltz, leading to the conclusion that the negotiating position of the state is given once for all, and is inseparably connected to geography. This point of view did not defend itself from criticism in modern times. In author's opinion, todays geopolitical reality should be studied from many perspectives, never excluding economy. Polish public debate needs revision of many popular theses and myths, especially about the absolute superpower of Russian empire in every single aspect, resulting from its military power.

Keywords: Russia, renewable energy sources, energy policy, the Baltic states

Renewable energy in Baltic states against Russian interests

Methodological basis and definitions

Keohane's and Nye's theory is based on conclusion that the modern state power is no longer estimated only by military strength. The consequent and spectacular growth of international trade brought decrease in relevancy of violent execution of decisions by superpowers, although the spectrum of sophisticated pressure methods actually has expanded. The new forms of control may cause even worse crisis in the weaker states than a military conflict.

Dependence on another economy and its resources may be divided into two kinds. The first is *"vulnerability"*. This kind of situations brings much risk to the weaker state because in case of any change (embargo, trade war, tariff increase) the state is forced to change its policy rapidly. The use of other state's vulnerability may lead to uncontrolled consequences. For example, the American blockade of Japanese foreign trade was a strong hit in the most sensitive point of Japanese vulnerability and brought counter-reaction of Japan in Pearl Harbor. This kind of interdependence occurs now between Russia and Baltic states – any blockade would potentially affect every side of the conflict, however Baltic states are *"vulnerable"*, which means that they are in danger of overwhelming crisis or even collapse.

The second kind of interdependence is *"sensitivity"*. This kind of situation differs from vulnerability in the level of severity in case of trade war. When a state is *"sensitive"* to another one's economy, any change in accessibility of its resources may cause negative impact, however it does not have to lead to painful economic crisis and risky counter-reaction such as war. During the fuel crisis in the early '70s, United States and other western countries were *"sensitive"*. They suffered a great cost of change in fuel supply but it did not lead to collapse and economic catastrophe (Keohane, Nye 1977: 13-17). In author's opinion, this kind of interdependence should be possible to reach by the Baltic states with investing in the renewable energy.

"Baltic states" term usually differs from "Baltic region". While the second one refers to any country with its coast line on Baltic sea (including Denmark, Germany, Russia etc.), the first one applies strictly to Lithuania, Latvia and Estonia, so is accepted in international nomenclature (Encyclopaedia Britannica). Polish tradition includes the term of "Inflanty" referring to historical Livonia, however it is not a synonymous term because Polish "Inflanty" excluded Lithuania, recognized as an integral part of Poland those times. Every usage of "Baltic states" term in this article refers strictly to republics of Lithuania, Latvia and Estonia.

Baltic energy markets

The Soviet Union collapse in 1991 caused big changes of the Lithuanian energy market. Until 2009, Lithuania was self-sufficient in the matter of energy and a large exporter of electricity, compared to its small territory. About 58% of annual production in Lithuania was exported.

That situation was bringing a big benefit for Lithuanian sovereignty, however it also generated a great risk. The Lithuanian electricity was mostly generated by the Ingalina nuclear plant, while it was an outdated Soviet construction identical to the one used until 1986 in Chernobyl. This situation caused an increasing pressure to close Ingalina, so it happened in 2009. Deprived of such an efficient energy source, Lithuania became dependent to electricity imports. In 2012, 63% of overall electricity imports in this country had its origin in Russia, 26% in Estonia, 7% in Latvia and 4% in Belarus (EIA 2013: Lithuania). Incidentally, absence of Poland in this enumeration is not a coincidence. Polish energy market is in extremely poor condition, moreover Poland becomes more and more dependent on electricity imports each year. Production of energy in Poland is so expensive that Polish state-owned enterprise created special limits for energy import from Lithuania because it was too cheap (CIRE 2016).

According to OECD data for 2016, 76% of whole Lithuanian energy market was generated by fossil fuels (excluding energy imports). Especially crude oil made 44% of it, natural gas 29%, coal 3%. The rest of energy came from the renewable sources – 22% from biofuels, 2% from sun/wind energy and the rest from water energy. Closing the Ingalina nuclear plant pushed Lithuania to import even 2/3 of its energy demand and now the main supplier is Russia. The worst level of vulnerability is actually occurring on the Lithuanian gas market – nearly 100% is provided by Russian Gazprom state company and it is claimed to be a monopolist. Lithuanian government has built LNG terminal in Klaipeda to escape from this extreme vulnerability level, however todays situation is far from the satisfying level of energy security (OECD 2019: Lithuania).

Latvia is placed in slightly different situation. Country produces low amount of energy and it does not have significant mineral resources. It the matter of fossil fuels, it is completely dependent on imports from Russia. The Latvian market is not substantially important for Kremlin, however Latvia plays an important role in natural gas transit to Europe and has built a big natural gas magazine to cover the higher demand on gas in winter (EIA 2014: Latvia).

Latvia today generates about 55% its energy needs. Comparing to Lithuanian 33%, Latvian result appears to be better. The reason lies in wide usage of renewable energy sources, together about 41% (33% from biofuels and 8% from hydroelectric power plants). The rest of the market is composed of crude oil and natural gas – coal does not play any important role (OECD 2019: Latvia). It is worth noticing that Latvia makes the positive energy trade balance. State-owned company Augstsprieguma tīkls declares that in March 2020 Latvia imported 239,8 MWh and exported 283,7 MWh, making it 45 MWh surplus. In comparison to March 2019 with 34,6 MWh surplus it may be found as a success (AST 2020).

Situation of Estonia is completely different. The country plays an essential role in transit of Russian petroleum to European Union with Muuga port (EIA 2015: Estonia). On the other hand, on the contrary to other Baltic states, Estonia has a noteworthy amount of natural resources. It is one of the few countries exploiting the oil shale as an energy source. Furthermore, tradition of oil shale exploitation reaches 80 years in this country and it is longer than anywhere else (Veiderma 2003).

Energy from oil shale and coal makes is 72% of the whole Estonian energy market and 76% of its electricity demand (IEA 2019). The other sources are mostly biofuels (17%), natural gas (7%), crude oil (4%) and other renewable sources just like wind and sun energy (1%). In fact, there are no hydroelectric plants in the country. This structure of national energy market makes Estonian government far more comfortable than Lithuanian or Latvian ones, even though the oil shale percentage decreased from 86% in 2013 (OECD 2019: Estonia).

Oil shale exploitation, including electricity and Diesel fuels productions, generates also big environmental costs. Estonia is the second European Union country by carbon dioxide emission per capita. It is remarkable that the first country in this ranking is Luxembourg – Poland, often accused of generating too much CO_2, makes it less than Netherlands or Germany (World Bank 2014). Calculating carbon dioxide units do GDP, Estonia appears as the most "polluted" economy in OECD. This situation causes harmful influence on people's health – in the areas near oil shale mines average life expectancy is 4 years lower, moreover children there much more often face problems with respiratory system.

European Union, concerned about Estonians sensitivity to Russian political influence, has made an exception for Eesti Energia state enterprise in 2012 and given an extra 18 million tons of carbon dioxide as a free addition to national emission limits. However, this is only a temporary solution. Estonia does not have a clear strategy to decrease its usage of oil shale and coal. Fear of falling into vulnerability from Russian energy is so big in Estonia that most of local politicians do not even consider decreasing the usage of oil shale nor investing in renewable energy (Randma 2018).

Reassuming, interdependence between Russia and Baltic states appears to be asymmetrical. Their national security is linked with North Atlantic Treaty Organization, but their energy security is connected to Russian market. According to interdependence theory, the stronger state puts effort to manipulate interdependence in areas in which they have advantages, especially when there are some areas where the situation is different (Nye 2009: 214). Russian energy policy is subordinated to balance the military presence of NATO in Baltic states.

Russian energy exporters perspective

Putting attention only to numbers, Baltic energy markets do not play a key role in Russian exports. Massachusetts Institute of Technology and its Observatory of Economic Complexity provided following data for 2017 Russian fossil fuels exports (OEC 2017):

- Crude petroleum – mainly exported to China (21%), Netherlands (15%), Germany (10%) and Poland (6,6%); Baltic states are significantly lower (Lithuania: 3,6%), at the end of the table (Estonia: 0,012%) or not even included (Latvia).
- Refined petroleum – Netherlands (14%), USA (11%), Turkey (5,8%) and Singapore (5,3%); for Baltic states Estonia makes it 1,1% and Latvia 0,24% – Lithuania not included.
- Natural gas – Italy (28%), Belarus (14%), Japan (12%) and Czechia (4,4%); in Baltic states Latvia (2,7%), Lithuania (1,7%) and Estonia at the end (0,68%). However, presented statistics appear to be incomplete, as official Gazprom delivery statistics mention Germany, Turkey, Italy and United Kingdom as the biggest importers (Gazprom Export 2018)
- Coal briquettes – South Korea (13%), China (11%), Japan (10%) and Germany (8,9%); in Baltic states Lithuania (0,4%), Latvia (0,2%) and Estonia (0,075%).

In sum, Baltic states together make it 3,6% in Russian crude oil exports, 1,34% in refined oil exports, 5,08% in natural gas exports and 0,65% coal exports. In the matter of electricity, Russia is not even the top exporter in the world, placed 11th in the world, ahead of Germany (the leader), Austria or even Czechia (The Global Economy 2018). It is caused by the fact that Russia produces enormous amounts of electricity to cover demand of its heavy industry. Minor volume of electricity is sold to the Commonwealth of Independent States (including most of the former Soviet states but not the Baltic ones). Russia buys even some portion of energy from Lithuania (Sidorenko 2011).

Economic profits from Baltic-Russia energy exports are not momentous for Russia, while Baltic states are strongly dependent on energy imports from this country. Under the interdependence theory perspective, Lithuania may be called extremely *"vulnerable"* with 2/3 energy imported. Estonia appears as *"sensitive"* country which probably could persist the blockade of energy trade with Russia, even facing painful impact on national economy. Latvia with covering about half of its energy demand by itself is still closer to *"vulnerability"* than *"sensitivity"*, however its ambitious renewable energy programme may turn the country more towards the second, more comfortable position. On the other hand, Russia is not even close to the *"sensitivity"* level in relations with Baltic states, however their membership in European Union common market forces Russia to be much more cautious in its decisions.

Nevertheless, importance of Baltic states in Russian national strategy may be much more significant. Keohane and Nye in their theory pay attention to agenda setting which means that non-military issues in foreign affairs play more significant role than ever (Keohane, Nye 1977: 32). Russian view on Baltic affairs can be described in two different ways. The first is presented by Polish political scientist and publicist Przemysław Żurawski vel Grajewski states that Russians are no more counting on the Baltic states transit role in their trade with EU, so they are capable of making even unprofitable decisions just for the geopolitical goals. Germany plays essential role as the most important trade partner for Russia in European Union and Russia may bear any cost to keep continuation of exchange with this country. Developing Primorsk port, building gas pipes directly to Germany (Nord Stream 1 and 2) are the most spectacular investments ancillary to this strategy. Latvia, which puts most effort to change their energy market structure, faced closing the Ventspils pipeline and blocking the railway od Narvik – it may lead to a reasonable conclusion that Latvian green energy investments concern Russians as a threat. However, Polish publicist claims that Baltic states transit role is not substantial (Żurawski vel Grajewski 2011).

Different point of view is presented by Dmitri Trenin, the Russian political scientist publishing in "Foreign Affairs". In his opinion, Baltic states play indispensable role in Russian political thought. Firstly, they are in fact the eastern flank of NATO and American military presence brings the risk to Kaliningrad Oblast and entire Russian national security. Secondarily, Baltic states are the place of living for significant Russian diaspora, facing many different form of discrimination (especially in Latvia they were not recognized as citizens for decades). Thirdly, United States constantly increase their activity in Baltic states (Trenin 2011).

Concluding the words of Trenin, it is reasonable to say that Baltic states are an important direction of Russian foreign affairs. It is also crucial to remember about the cultural context and Russian imperial tradition, leading the Kremlin elites to negotiate only with similar powers and treat smaller states in their traditional influence area as passive objects. Situation between Russia and Baltic states is an example of Nye's statement that separation of domestic and foreign policy is blurred in the modern world (Nye 2009: 211). The situation of Russian minority in Baltic states is not only a problem between two sovereign states, but also an internal problem of Russian nation.

Transit and strategical position of Baltic states is found in Moscow as one of the biggest threats to global energy security (Porębska, Księżopolski, 2016: 354). In author's opinion it is existential need for Baltic states to limit their *"vulnerability"* from Russia because its authorities can be intent to use even drastic forms of pressure.

Renewable energy and possibilities of change

Arguments for utmost inequality in Baltic-Russia energy trade were mentioned by author in the previous sections. Estonia shows itself as an exception with average dose of energy sovereignty, however the country pays big price for it – high level of pollution and inevitable increase of pressure from the European Union to reduce it. There is also a noticeable cultural aspect of the case. Estonians find themselves more Nordic than Baltic, and have even created their own unofficial flag with Scandinavian cross (Simonson 2018). Scandinavians are actually strong in their pro-ecological attitudes and eventual rapprochement may be interrupted by air polluting by Estonians.

Most of the scenarios for Baltic response for Russian pressure include regional integration. Dr Frank Umbach states that the optimum plan (despite the existing LNG terminal and diversification of gas supplies) is integration of Polish, Nordic and Baltic electrical grid. Baltic states gained support from European Union in the Third Energy Package for this objective (Umbach 2015). Warsaw Institute states that this initiative is proceeded on three links – Estonian-Finnish (EstLink 1 and 2, overall 1000 MW), Lithuanian-Swedish (NordBalt, 700 MW) and Polish-Lithuanian (Lit-Pol Link, 500 MW). However, energy independence from Russia appears as a distant goal (Warsaw Institute, 2018).

Lithuanian crucial need for investments in renewable energy is not ignored by country's authorities because it is mostly affected by dependence on Russian resources. The state-owned enterprise Lietuvos Energija is planning to invest amount of 6,2 billion Euro for production and distribution of national renewable energy. Green-field investments are planned in the country and abroad, especially in Poland and other Baltic states. LE sets an ambitious goal to gain full energy independence in 2050 with 80% of national energy coming from renewable sources. Lithuanian government appears to be aware of potential change in country's potential with renewable energy (Gram W Zielone, 2018).

Dynamic progress of renewable energy in Latvia does also appear to have possibilities for ongoing. Latvian government has an extremely ambitious objective to gain full climate neutrality until 2050, which means abandoning all the traditional energy sources. Polish Institute of International Affairs informs that overall cost is planned to reach about 8 billion Euro for infrastructural programs in industry, transport and agriculture (Raś 2020).

Estonia is not forced to change its energy policy rapidly, so that changes are coming slowly. However, “sensitive” dependence on trade with Russia does not mean that country is perfectly safe from pressure, moreover Estonian people are suffering health problems connected to fossil fuels exploitation. The local strategy begins from the household level – Eesti Energia offers its customers buying a “green package” with a guarantee that electricity in their home would be always powered from renewable sources (Biznes Alert, 2018). Estonia invests more in windmill generators than in hydroelectric plants.

In case of Russia, setting such goals as climate neutrality is hardly believable because of tremendously high level of energy demand created by the country's heavy industry. With its vast land area and many long rivers, Russia could potentially use natural advantages to provide great amount of energy created by renewable sources. However, this potential remains unused because of subordination of country's energy sector to to its geopolitical strategy and its property structure. Most of the Russian natural resources are controlled by local political and business elite called “oligarchs”. Having in mind the Jukos case and proceeding the right for state enterprises to overtake natural resources without call for bids, it is reasonable to stand that Vladimir Putin's administration constantly endeavoured to take control on the whole energy production in the country for the last 20 years (Molo 2008). Renewable energy always cuts across the interests of Russian national elites operating in fuel industry, no matter if on domestic market or abroad.

Conclusions

The main conclusion of this article is that Keohane's and Nye's complex interdependence theory applies to Baltic-Russia relations. Energy sources import from Russia is essential to Baltic markets, appropriately less for Estonia and most for Lithuania. In Russian geopolitical perspective, Baltic states are irrelevant in economic sense but significant because of their transit role, military presence of NATO and Russian diaspora living there.

Russia consequently lowers its level of interdependence and sensitivity by building ports (Primorsk) and gas pipelines (Nord Stream 1 and 2, Turkish Stream and the Power of Siberia). According to the national resources and huge land area, Russia is capable of gaining economic independence. On the other hand, Baltic states (except Estonia) are still very vulnerable for any change. Their small territory and the big scale of Russian investments in pipelines are strong disadvantages for them. Building the LNG terminals may be kind of escape from this trap, however capabilities of this solution are limited. It also does not change the main problem – country energy market is still dependent on foreign sources, the only change is changing the supplier.

In author's opinion the only chance for Baltic states to improve their national energy markets and provide energy security is the renewable energy. Wind, biofuels, sun and water are resources that may be provided by national market, regardless of the external suppliers (Russia, Germany or any other). Their availability is also not sensitive for exhaustion. So that, if the positive trend in renewable energy in Baltic states continues, their risk of energetic blackout will decline. Investments in renewable energy are rational for them because of environmental benefits and also their reason of state.

Bibliography

1. Robert Keohane, Joseph Nye, *Power and interdependence: world politics in transition*, Little, Brown and Company, Boston 1977
2. Encyclopaedia Britannica, *Baltic states*, https://www.britannica.com/place/Baltic-states (dostęp: 13 maja 2020)
3. Encyklopedia PWN, *Inflanty*, https://encyklopedia.pwn.pl/haslo/Inflanty;3914680.html (dostęp: 13 maja 2020)
4. *Lithuania*, U.S. Energy Information and Administration, https://www.eia.gov/international/analysis/country/LTU (dostęp: 13 maja 2020)
5. *PSE wprowadza limity na import energii z Litwy*, https://www.cire.pl/item,130228,1,0,0,0,0,0,pse-wprowadza-limity-na-import-energii-z-litwy.html (dostęp: 13 maja 2020)
6. *Fossil fuel support country note – Lithuania*, OECD Report, 2019
7. *Latvia*, U.S. Energy Information and Administration, https://www.eia.gov/international/analysis/country/LVA (dostęp: 13 maja 2020)
8. *Fossil fuel support country note – Latvia*, OECD Report, 2019
9. *Latvian electricity market overview*, AST official data, http://www.ast.lv/en/electricity-market-review (dostęp: 13 maja 2020)
10. *Estonia*, U.S. Energy Information and Administration, https://www.eia.gov/international/analysis/country/EST (dostęp: 13 maja 2020)
11. M. Veiderma, *Estonian oil shale – resources and usage*, 2003 Estonian Academy Publishers, http://www.kirj.ee/public/oilshale/3_veiderma_3003_3s.pdf (dostęp: 13 maja 2020)
12. *Estonia*, International Energy Agency data, https://www.iea.org/countries/estonia [dostęp: 13 maja 2020]
13. *Fossil fuel support country note – Estonia*, OECD Report, 2019
14. *CO2 emissions – metric tonnes per capita*, World Bank, https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?most_recent_value_desc=true (dostęp: 13 maja 2020)
15. *Estonia's dirty secret*, https://bankwatch.org/blog/estonia-s-dirty-secret-oil-shale (dostęp: 13 maja 2020)
16. Russia, Observatory of Economic Complexity, https://oec.world/en/profile/country/rus/ (dostęp: 13 maja 2020)

17. *Delivery statistics*, Gazprom Exports 2018, http://www.gazpromexport.ru/en/statistics/ (dostęp: 14 lipca 2020)
18. *Electricity exports - Country rankings*, The Global Economy data, https://www.theglobaleconomy.com/rankings/electricity_exports/ (dostęp: 13 maja 2020)
19. Alexandra Sidorenko, *Electricity in Russia*, APEC Reports 2011, http://publications.apec.org/-/media/APEC/Publications/2011/1/The-Impacts-and-Benefits-of-Structural-Reforms-in-Transport-Energy-and-Telecommunications-Sectors/TOC/Electricity-in-Russia.pdf (dostęp: 13 maja 2020)
20. Przemysław Żurawski vel Grajewski, *Strategia Federacji Rosyjskiej wobec państw basenu Morza Bałtyckiego*, Analizy Natolińskie 4/2011
21. Dmitrij Trenin, *Russian Policies toward the Nordic-Baltic Region* [in:] *Nordic-Baltic Security in the 21St Century: The Regional Agenda and the Global Role*, Atlantic Council Report, 2011
22. Joseph Nye, *Understanding international conflicts: an introduction to theory and history,* Longman classics in political science, 2009
23. Kamila Porębska, Krzysztof Księżopolski, *Revolution in renewable energy technologies and international relations* [in:] Monika Szkarłat, Katarzyna Mojska, *New technologies as a factor of international relations,* Cambridge Scholar Publishing, Newcastle upon Tyne 2016
24. *The case for an Estonian Nordic flag*, https://estonianworld.com/opinion/a-case-for-an-estonian-nordic-flag/ (dostęp: 13 maja 2020)
25. Dr Frank Umbach, *Baltic energy security – no longer a regional energy Island*, Geopolitical Intelligence Services, https://www.gisreportsonline.com/baltic-energy-security-no-longer-a-regional-energy-island,energy,229.html (dostęp: 13 maja 2020)
26. *The electrical synchronisation of Baltic states is getting closer*, https://warsawinstitute.org/electrical-synchronisation-baltic-states-getting-closer/ (dostęp: 13 maja 2020)
27. *Litewski potentat stawia na OZE. Chce inwestować m.in. w Polsce*, https://gramwzielone.pl/trendy/31257/litewski-potentat-stawia-na-oze-chce-inwestowac-min-w-polsce (dostęp: 13 maja 2020)
28. Kinga Raś, *Polityka klimatyczna Łotwy*, April 2020, Polski Instytut Spraw Międzynarodowych
29. *Estonia coraz chętniej sięga po OZE*, https://biznesalert.pl/estonia-oze/ (dostęp: 13 maja 2020)
30. Beata Molo, *Polityka bezpieczeństwa energetycznego Federacji Rosyjskiej* [in:] Erhard Cziomer, *Międzynarodowe bezpieczeństwo energetyczne w XXI wieku*, Oficyna Wydawnicza AFM, Kraków 2008

Grażyna Mórawska, M.A., M.A. in political sciences (2019), absolvent of the Jagiellonian University in Kraków, currently a student of international studies at the Jagiellonian University. Her scientific interests focus on energy policy, realism in international relations and Russian foreign policy.
ORCID: 0000-0001-6503-4031

The Cold Gas War: the Strategies of Russia and the USA in Europe

Valerio Tati

Abstract: The main purpose of this article is to analyse the European situation in the field of natural gas supply. The article mainly focuses on the energy behaviour of two countries: Russia and the United States of America. Different countries but with similar purposes, as they both aim to limit the power of control of the other in the old continent, using natural gas (Russia) and LNG (USA) as a weapon. This document, in order to arrive at describing the current situation of the "cold gas war", starts from an historical excursus of how and when the two energy powers began to impose themselves on the world level until today, the current "clash" for the search of dominance over Europe. For the writing of this article, since these are very topical topics, several articles from organizations and journals (e.g. The Economist"), specialized in energy and also geopolitics, have been used. The use of papers from the International Energy Agency (IEA), the Oxford Institute for Energy Studies, was also of fundamental importance in achieving the aim of the article.

Keywords: natural gas, LNG, USA, Russia

Introduction

On 9 November 1992, one of the most significant events of the 20th century took place: the fall of the Berlin Wall. That wall, a symbol of the division of the world into two marked blocks, represented not only a physical border, but also a cultural, economic and ideological division, due to the dominant nations of the two blocks, which were to underline the clear division that had been created in the Western world. The main architects of the division of the globe were two, the two super powers that had won the Second World War: the USSR and the United States of America.

These states aimed to expand their sphere of influence. The implementation of their plan was carried out through the use of "classic" means (economic support, military technology) and less classic means, such as "soft power" (it involved the use of means that had a great emphasis on the population such as cinema, books, sport).

Today, instead, after years of apparent tranquillity from the geopolitical point of view, we are returning to a climate of high tension due to the clash, once again, between the usual two super powers: The United States and Russia. This time, however, the instrument used to increase the power of influence is Gas.

Over the years, natural gas is becoming more and more established as a key element, mainly because of its importance at an energy level (an increasingly decisive energy source) but also because of its weight at a geopolitical level. The twenty-first century is becoming increasingly characterised by an increase in the demand for raw materials, in particular an increase in the demand for gas. This increase is mainly due to the increase in population, but also to the growing production activity that is increasingly concentrated in certain areas of the world.

All these factors necessarily lead states to enter into agreements and contracts with different suppliers, trying to secure a secure supply.

Europe, in particular the Mediterranean area, and the so-called Eurasia are, today, the territories where the new "cold war" is taking place. The main players in this power game are two superpowers that are characterized by a high level of energy independence and have conflicting strategies. (Muratore 2019) On one side of the chessboard we can find the Russia of the "czar" Vladimir Putin, who aims to strengthen and consolidate the strategic role of the Russian Federation as a strategic supplier of the old continent, also looking towards the Eastern market, in particular the flourishing Chinese market. While on the other side we can find the United States, which in recent years, thanks to the surge in shale oil and shale gas, have become the world's leading producers of natural gas. What is more, with the recent decision of the American President to liberalise exports, the conquest of the world energy market has begun. An America first again in the energy field with the preeminent goal of eroding influence in Russia's energy markets. (Bessi 2018)

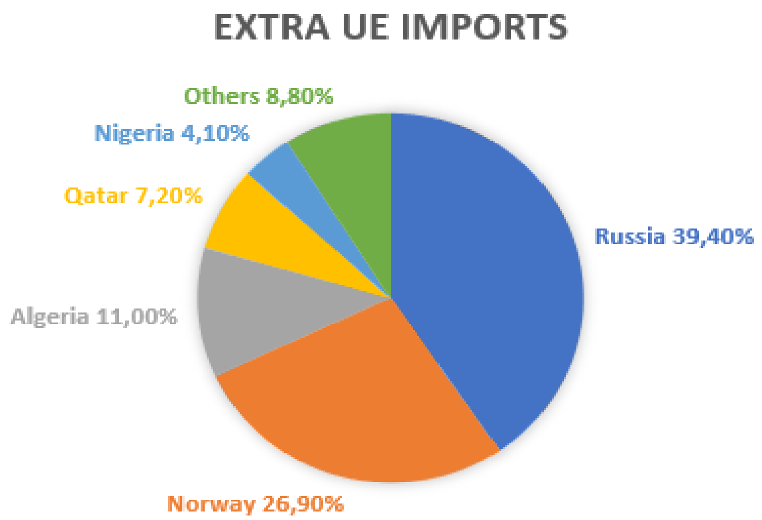
Strategy

The concept of "energy security" has become increasingly topical in the last decade, as access to energy resources is vital for importing countries, especially to ensure the smooth running of the activities of industrialized companies. Because, in the event of a sudden and prolonged suspension of energy supplies, it would deprive the importing states of the possibility of the normal performance of the fundamental and vital activities of every developed city. Different definitions can be found in the literature regarding the meaning of "energy security". Most of these definitions are accumulated by the basic idea that the availability of energy does not undergo sudden changes with respect to domestic demand. (Winzer 2011) A first group of definitions of energy security is the one that is based on the concept of security as the continuity of the energy good. A first definition of this group is that of the Department of Energy and Climate Change (DECC) which states that "secure energy means that the risks of energy supply disruption are low" (DECC 2009). Following the same logical line, other explanations can also be recalled, such as the one given by Sheepers, which explains energy security as "a security of supply risk refers to a shortage in energy supply, either a relative shortage, i.e. a mismatch in supply and demand inducing price increases, or a partial or complete disruption of energy supplies… A secure energy supply implies the continuous uninterrupted availability of energy at the consumer's site" (Scheepers 2007); or as the Lieb-Dóczy definition that shows us the concept of energy security as "security of supply is fundamentally about risk. More secure systems are those with lower risks of system interruption" (Lieb-Dóczy 2003). One could also cite Wright who, in his paper Liberalisation and the security of gas supply in the UK, supports the idea that 'security of gas supply': "an insurance against the risk of an interruption of external supplies" (Wright 2005).

In addition to these definitions which are based on the concept of continuity of energy supply, other "groups of definitions" can also be found in the literature which differ in small nuances. We have the definitions of the "second group" which also introduce the concept of subjective gravity filters to distinguish between safe and insecure energy sources. Of this group the most representative explanation is given by the International Energy Agency (IEA) which states that "energy security is defined in terms of the physical availability of supplies to meet demand at a given price" (IEA 2001). This concept, wants to reiterate that, raising the extreme case of energy disruption, energy security can only be questioned if energy scarcity compromises the level of prices, bringing them to a level above a certain critical threshold. Again, following the same critical line, in the literature we can find other definitions that follow on the false line that of the International Energy Agency, such as that of Vicini et all which states that “energy security is defined as the availability of a regular supply of energy at an affordable price. The definition has physical, economic, social and environmental dimensions; and long and short term dimensions” (Vicini 2005). Or as the definition of Le Coq at al. "supply security, usually defined as a continuous availability of energy at affordable prices" (Le Coq 2009). To conclude, we can also cite Jun at all who in their paper support the thesis that "energy security can be defined as a reliable and uninterrupted supply of energy sufficient to meet the needs of the economy at the same time, coming at a reasonable price" (Jun 2008).

Finally, we have the definitions of "third group". These focus more on measuring the impact of energy. They are therefore based on energy price and energy continuity impact measurement. An example can be made by referring to the definition of Noel and Findlater "security of gas supply (or security of gas supply) refers to the ability of a country's energy supply system to meet the final energy demand contracted in the event of a gas supply disruption" (Noel 2010), where final demand refers to energy services that are used in everyday life. Also of this group's generation, other similar definitions can be found in literary culture such as Patternson which states that "the energy security that worries politicians concerns supplies of imported oil and natural gas, not the secure delivery of energy services, such as keeping the lights on" (Patterson 2008), or Bohi et al. which defines "energy insecurity can be defined as the loss of well-being that can occur as a result of a change in the price or availability of energy” (Bohi 1996). Or again Lefèvre 2009, who in his article states that "energy insecurity can be defined as the loss of welfare that may occur as a result of a change in the price or availability of energy" (Lefèvre 2009).

Figure 1. Extra-EU imports of natural gas from main trading partners first semester 2019



Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Extra-EU_imports_of_natural_gas_from_main_trading_partners,_2018_and_first_semester_2019.png

Analysing the situation in Europe to date, it can be said that the old continent is at the limits of energy security. Taking into consideration the latest data from Eurostat (European Commission 2018), as far as gas supply is concerned, Europe imports a significant quantity of gas (39.4%) from Russia. In itself, this figure should not cause problems if we were talking about a reliable nation, from the point of view of energy security, but given that we are talking about Russia, this figure could be alarming: this is what history tells us.

In the first decade of the twenty-first century, more precisely from 2000 to 2008, Gazprom was one of the main actresses in the European energy scene, managing well to manage the continuous upward change in the prices of oil and natural gas and to exploit the growing global demand for energy resources. Russia has always been the main energy supplier to the old continent. (Ercoli 2019)With the collapse of the Soviet bloc some states have moved away from the sphere of Russian influence (as was the case with the countries of Central and Eastern Europe in the 1990s), approaching, in some cases, the EU or NATO. This substantial departure from Moscow has had serious repercussions on energy supplies from Russia: in fact, Gazprom applied considerably higher prices to "dissident" countries than the previous cheaper prices. This also had political repercussions between Russia and the governments of the former Soviet bloc. This Russian attitude in the use of "energy diplomacy", using the supply of gas as a real political tool, has always, but especially in the last period, increased the mistrust in the EU towards the Kremlin.

It is enough to remember the gas crisis between Russia itself and Ukraine in 2006, when Gazprom closed the gas taps towards Ukraine, putting in great difficulty the government in Kiev but also Europe itself, as Ukraine represents a fundamental junction for the distribution of natural gas in the old continent. (Ruszel 2019) Other examples can also be given of the blackmailing policy of the Kremlin and in particular of Gazprom, towards European countries, especially those countries that orbited in the Soviet orbit, as we have seen previously with Ukraine. (IEA and KEEI 2019) Another significant case was the "gas war", which took place in 2004, between Moscow and Minsk when Gazprom refused to sign and consequently to renew the supply contract with the Belarusian government, thereby suspending the supply of gas. (Bessi 2019) The basic problem between the Kremlin and Minsk was the pressure on Minsk from Russia to accept higher gas tariffs from the Belarusian government and to sell Beltransgaz, the Belarusian gas pipeline operator, to Gazprom, especially on favourable terms. (Smolinova 2014)

Since the annexation by Europe of the former Soviet states of Central and Eastern Europe, and the consequent disruption of gas supplies, especially through the territories of Kiev, Brussels has increasingly considered the need to diversify energy imports to avoid relying solely on the Russian monopoly power.

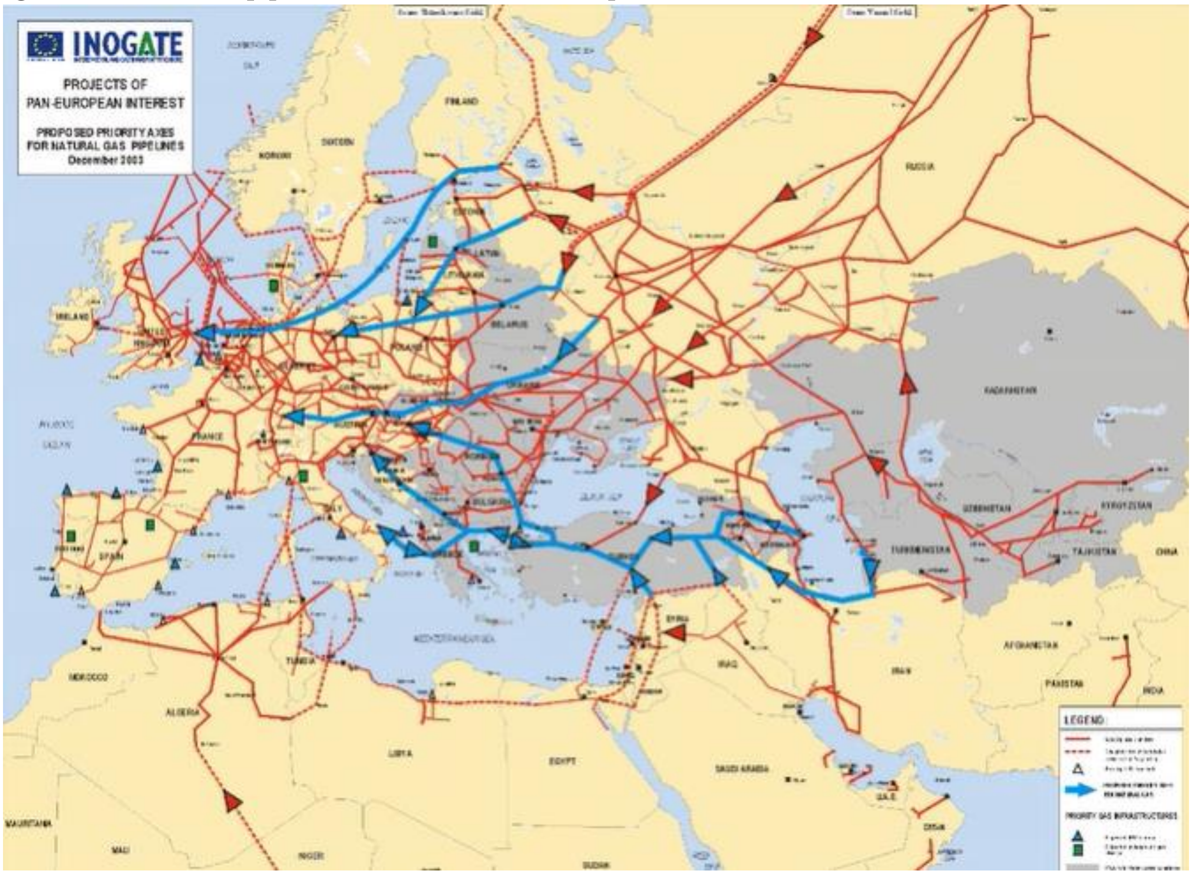
For this reason, the European Commission in recent years has launched a number of different projects with the aim of expanding the possibilities of energy supply, such as the TAP project (which aims to import gas from Azerbaijan) and East-Med (which aims to import gas from the Caucasus). (Ercoli 2019) The European Commission has always fought in favour of the use of LNG as an essential source for energy diversification: in fact, Brussels has repeatedly reiterated its intention to guarantee each member state direct or indirect access to LNG.

Russia

Russia has the largest natural gas fields in the world. The total capacity of these fields is 48 trillion cubic metres which are mostly concentrated in the fields of Eastern Siberia. The maximum expansion of Russian gas production began in the 1980s, when the use and distribution of natural gas outstripped that of oil, mainly due to the lowering of gas extraction costs compared to oil. In fact, in that period, although oil was always the most produced energy resource, the production of natural gas grew by 50% during the eighties. (Grigas 2017) After the collapse of the wall, and the subsequent dissolution of the USSR, there was a change of course in the production of gas and oil. With the dissolution of the Soviet Union, there was a marked collapse in oil production, while gas production remained almost stable and even grew during the nineties. This situation was made possible by the greater stability in the gas market that occurred after the former Ministry of Gas was converted into the current state-owned company Gazprom.

As mentioned earlier, the "glorious history" of Russian gas domination began in the 1980s, but the important role of gas supplier began in the late 1960s: in fact from that date the Soviet Union began to export its gas to the "satellite" countries. (Austvik 2015) The first supply was of 3 billion cubic meters of gas, divided between Poland, Czechoslovakia and Austria. Starting in the 1980s, natural gas exports reached 56 billion cubic metres to be divided between, in addition to the countries mentioned above, Western Germany, Romania, Hungary, Bulgaria and Yugoslavia, but also managed to expand its export range to Western European countries (Italy, France and Western Germany). (Grigas 2017)The production and export of Russian natural gas continued to increase, reaching a peak of 248 billion cubic metres of gas in 2008.

Figure 2. Natural Gas pipelines from Russia into Europe.



Sources: https://www.reddit.com/r/MapPorn/comments/1zhlnw/natural_gas_pipelines_from_russia_into_europe

However, from the mid-2000's, Russian gas exports to the old continent suffered a sharp slowdown mainly due to two factors: the drop in energy demand, due to increasing energy efficiency, and the increased use of renewable energy (wind, solar) and also of energy sources at sufficient cost such as coal (Grigas 2017).

Gas and politics, especially in the case of Russia, are two elements that move on the same track: one cannot ignore the other. Indeed, since the beginning of the gas trade with European countries, the Kremlin has always demanded something in return. For example, during the Cold War, Moscow demanded, in exchange for Russian gas, technological materials and industrial items. (Hogselius 2013)

The commercial and, above all, political influence on exporting countries has always characterised the commercial exchange of gas between the Kremlin and other countries. Thanks to its dominant and monopolistic position in the gas market, Gazprom could afford this aggressive attitude towards European states (Melchiorre 2006).

Russia's gas is also used as a geopolitical tool: in fact, it is used as a "soft power" to manipulate and influence the geopolitical choices of importing governments. To affirm and confirm this attitude are the same Russian politicians and administrators: in fact, in 2003, on the occasion of the tenth anniversary of the state-owned company Gazprom, President Putin states that: "Gazprom is a powerful political and economic lever of influence on the rest of the world if the leaders of this or that country decide to show goodwill towards the Russian Federation, then the situation with gas supplies, pricing policy and the previous debt changes on a note much more favourable to the buyer".

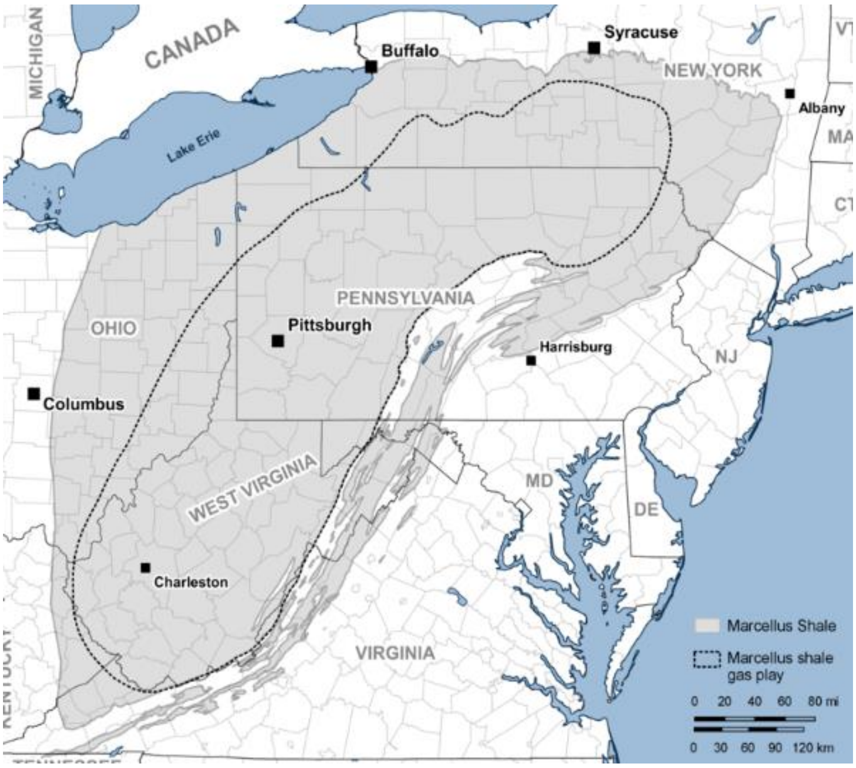
Gazprom has often found itself lobbying, especially in its monopoly markets (Belarus, Ukraine and Armenia), for political concessions in exchange for lowering the price of gas. (Ruszel 2019) However, all the commercial and pressure manoeuvres carried out by Gazprom are actually dictated by the central government in Moscow. (Bessi 2019)Therefore, it can be said that Gazprom's decisions marry the political lines with the objectives of the Kremlin. Very often, Russia has distinguished itself in having carried out energy interruptions towards those nations that, with their behaviour, did not "cooperate" to reach the objectives set by the Kremlin. Suffice it to mention the cases of Belarus, Ukraine or Latvia. (Smolinova 2014)

It can be said that the way Gazprom, and therefore the Kremlin, has acted has been to offer more fragile countries, politically and economically, such as Armenia, Belarus or Kyrgyzstan, gas at low prices. At the same time, however, these countries were indebted to the Russian company. At the same time, the Russian company, strengthened by its credit position, was able to obtain, as compensation for debts, at very low prices, the energy structures of the debtor countries or by making political concessions. In this way, both the Kremlin and Gazprom were able to emerge as winners, increasing in both cases their influence and control over their importers (Cornot-Gandolphe 2016).

The United States of America

The United States has always played a major role in the production and extraction of primary energy. The U.S.'s focus on primary energy began with the end of the Cold War, as the Washington government was able to focus more on its national interests (such as procurement of raw materials) rather than worrying about maintaining useful alliances during the Cold War period with the aim of containing the advance of the Soviet Union's overwhelming power. (T.Klare 2002) But it was only at the end of the 10's of the 2000's that they began to establish themselves internationally. The domestic energy markets, especially the gas market, were highly unstable with great price volatility. They tended to peak at the beginning of the 2000s, until they collapsed year after year at the end of 2011. (Pustišek e Karasz 2017) The main cause of this instability in natural gas prices is mainly to be found in the large production of gas by American companies. The great expansion of natural gas in recent years, also due to new techniques of extraction of the raw material, has led to the modification of the internal market for gas. (Grigas 2017)

Figure 3. Marcellus Ground



Sources: https://en.wikipedia.org/wiki/Marcellus_natural_gas_trend#/media/File:Marcellus_shale_revised_map_2019.png

The exponential production of natural gas in the United States has been characterized by the greater exploitation of the large gas fields present in the American soil. The main U.S. gas formations are respectively Marcellus (located in Utica in the Appalachian Basin). This formation reaches a depth of 8500 feet, and its size is such that it can "touch" 4 states: New York, West Virginia, Pennsylvania and Ohio. Given the size of this deposit, it manages to produce 18 BCF of gas per day and Haynesville located between East Texas and West Louisiana. These are the fields that will supply the largest amount of natural gas from 2014 onwards. With the US gas revolution, many foreign energy companies decided in 2013 to make massive investments in projects that aimed to export gas outside the US, and to obtain a preferential channel for gas sales. Exports of gas, not via pipelines, would not be possible without liquefaction and regasification plants. The former serves to allow the transport of gas in particular containers. (Barlaam 2019)There are several liquefaction plants in the USA to date: the Sabine Pass plant in Cheniere, on the border between Louisiana and Texas, the Cameron LNG plant in Hackberry, Louisiana Kenai in Nikiski, Alaska, the Freeport LNG plant in Freeport, Texas, and the Dominion Cove Point plant in Cove Point, Maryland. (The Economist 2018) All these plants give us the total export capacity of the United States, which is about 3 billion cubic feet at the beginning of 2019.While the latter are essential for the reception of imported gas, which allow the same gas to return to the gaseous state. (IEA and KEEI 2019)

The cold (gas) War

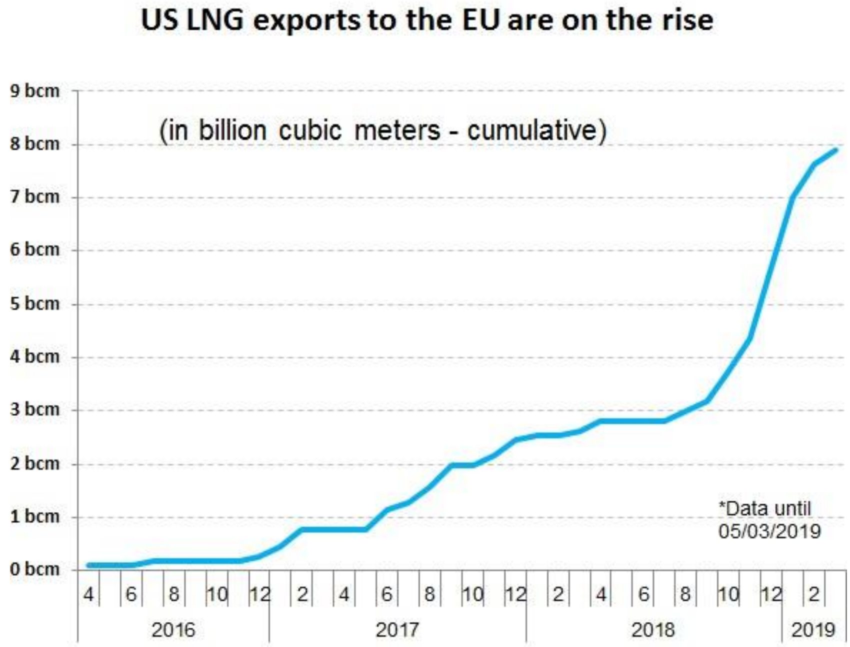
Today in Europe, a new "cold war" is taking place in the field of energy, which is not fought militarily or through the use of ideologies, as in the past, but through the use of gas. The "Gas States (Russia and the USA), the main actors of this war, clash on European territory with new trade agreements and the construction of new pipelines. (Bessi 2019)One of the reasons for this dispute is that the gas market is becoming increasingly important at world level, getting closer to the rich oil market for the amount of trade that is made.

In this "war" the nation that appears to be advantaged, at least in the beginning, is Russia. The great privilege of the Kremlin is, first of all, the possibility of selling its gas to European states at a low prices compared to other gas producers. Another advantage is the ease with which Moscow can easily transport its own gas throughout Europe, through the dense network of pipelines that cover the whole of the Old Continent. All these advantages of Russia in the European gas market have always frightened the likely competitors to enter this market as alternatives to Russia itself. (Dell'Olmo 2019) A turning point for the interruption of this hegemony could be marked by the introduction of LNG in the European market, especially from whit United States. The main problems for which LNG has not been able to impose itself on the European market so far are the long distance from the producing countries and the high price, compared, for example, to Russian gas. But these difficulties could be overcome by the construction of additional liquefaction and regasification plants for LNG. The increased presence of gas coming from outside Russia would be optimal, above all, to ease the geopolitical tension arising from Moscow's semi-monopolistic position vis-à-vis European countries.

This war has a fairly recent origin because, as mentioned above, the United States is recently imposing itself in the gas market. Unlike Russia, which has always played an important role in gas distribution since the Soviet Union.

The main question to ask is why has the Trump administration decided on this sudden acceleration in gas production? The main reason for this is the need on the part of the United States to consolidate the state budget (reduced after the application of the tax reform) but also the trade balance (especially in the manufacturing sector due to competition from China and India). Another reason for this concentration of the White House, on the production but above all also on the export of gas, concerns, as Russia teaches, the use of gas, in particular LNG, as a powerful means of control and influence of the policies of the importing states: in fact, LNG is becoming more and more a fundamental and pre-eminent element in the European economic and geopolitical spheres: In fact, the massive presence of US gas, and not only, could free Europe from the dependence of Russian gas and thus make the European Commission more free to apply, with greater relief, sanctions to inappropriate behaviour of the Kremlin (such as the annexation of the Crimea). (The Oxford Institute for Energy Studies 2019)For this reason, the USA, in recent years has signed agreements with the European Commission and also, in a very special way with some European countries, two above all Poland and Ukraine, several agreements for the sale of LNG with the official objective of wanting to reduce Europe's dependence on Russian gas pipelines. (Ercoli 2019)

Figure 4:US LNG exports to the EU are on the rise



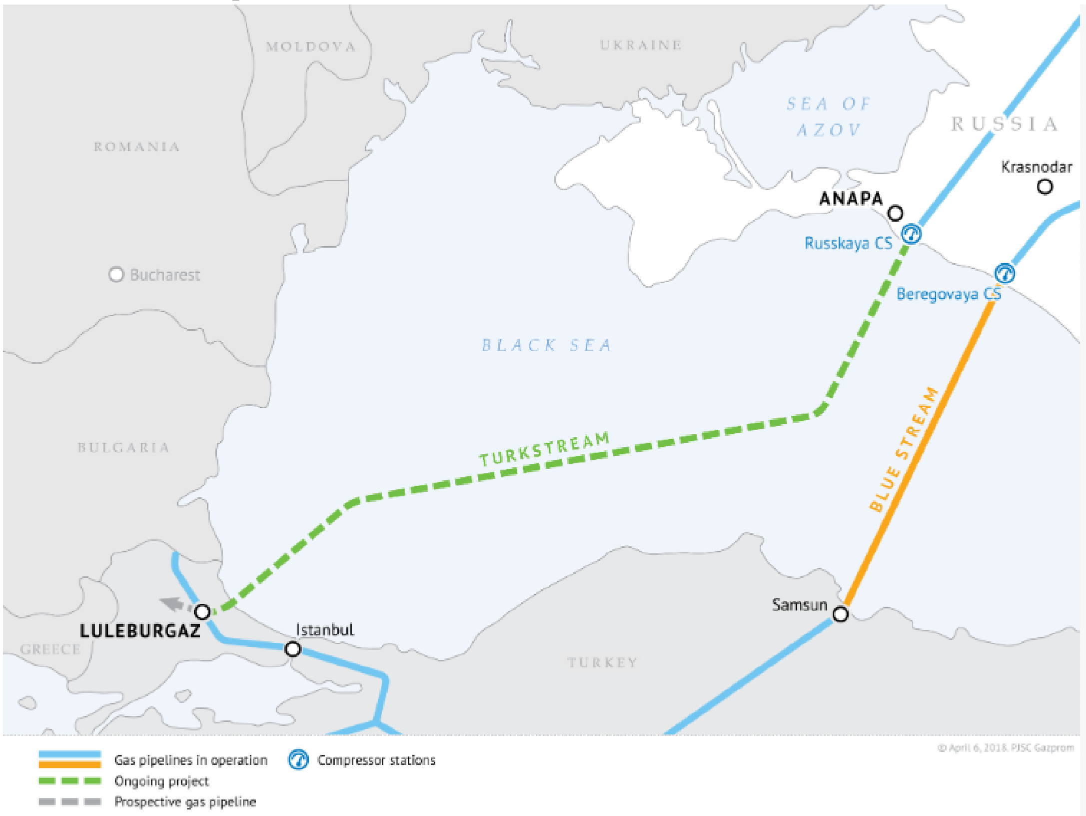
Source: https://ec.europa.eu/commission/presscorner/detail/es/IP_19_1531?

However, in order for the United States to "free" Europe from the grip of Russian gas, the old continent must have regasification plants in order to accommodate US LNG vessels. Without them it would be impossible to obtain gas with stars and stripes (Molnar, et al. 2015). The situation in Europe with regard to the presence of regasification plants is quite critical because most of the plants are located in Western Europe (the European area that is potentially less blackmailed by Russia) while in Central and Eastern Europe there are only two regasification plants (one in Poland and the other in Lithuania). This situation leads to numerous disadvantages for the countries of the former Iron Curtain to obtain the American LNG. In addition to the regasification plants, the so-called cross-border pipelines are also of fundamental importance. These are pipelines that run from countries that import LNG to countries that do not have an outlet to the sea. An example is the construction that is taking place on the island of Krk, which has the main objective of supplying US LNG to all the countries of the Balkans and Central Europe. But among these agreements there is also a second aim: to reduce and limit Russia's power of control and influence in the European chessboard. (Grigas 2017)

In any case, the opening of Brussels to the US LNG, was a hard blow for Gazprom, and therefore for Russia itself. In particular, it accused the continuous fall in prices of being decisive in undermining Gazprom's domination. The Russian state company, however, has tried in recent years to modify its contractual offers (guaranteeing lower prices but and longer contracts) without however obtaining great results. (Vita 2019) However, at least for the moment, the situation of Gazprom is not dramatic. Many long-term contracts are still in force, which gives Gazprom strong bargaining power. As an extreme hypothesis, it could apply an aggressive price policy to counter the advance of gas with stars and stripes in the European market (The Oxford Institute for Energy Studies 2019). In other words, to apply very low prices to discourage the various competitors from entering the European market. Obviously, the consequences for Gazprom would be a reduction in profits.

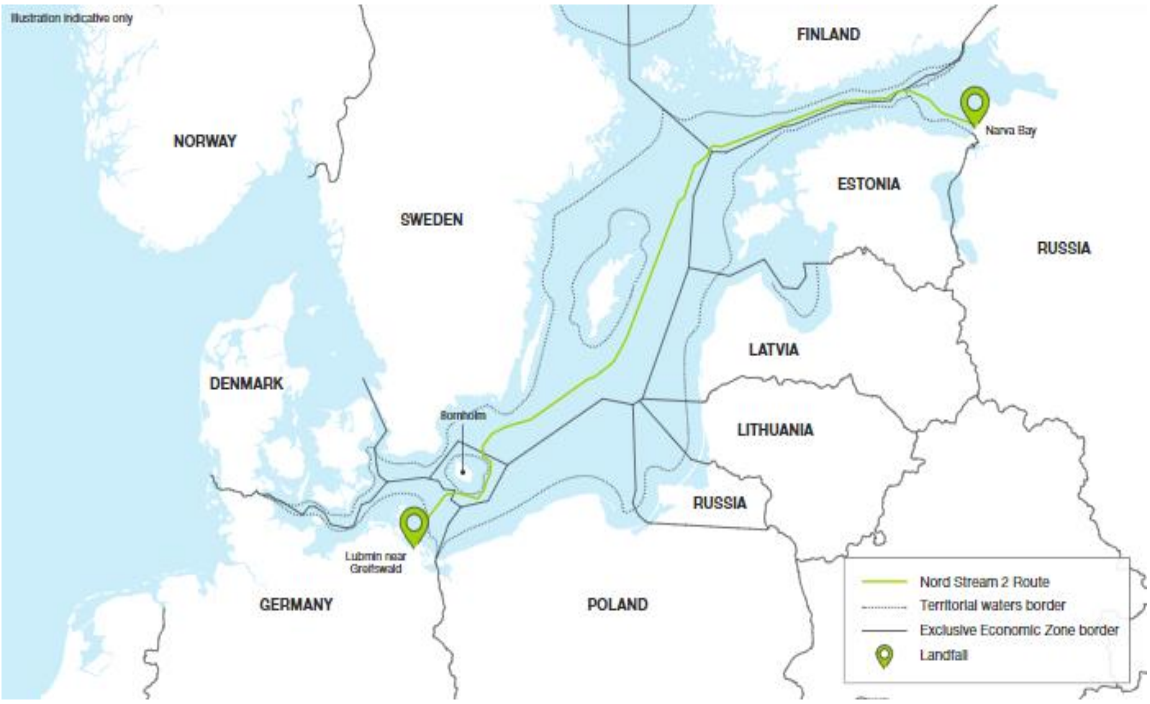
Obviously Russia, to avoid being dethroned by the United States in the sale of gas in the old continent, has not remained to look motionless agreements between Brussels and Washington. On the contrary, it has moved to build new gas pipelines and enter into new trade agreements with the aim of consolidating its position of hegemonic strength. The main projects carried out by the Kremlin are two: Nord Stream II (a doubling of the existing infrastructure, which allows 55 billion cubic metres of gas to be transported annually from the Russian coast near St Petersburg to northern Germany via the Baltic Sea (The Economist 2019)) and Turkish Stream (The project involves the construction of two branches, each of which can transport 15. 75 billion cubic metres of gas per year). (Vita 2019) The first line will be entirely dedicated to the energy supply of Turkey. The second should supply Russian gas to the countries of southern and south-eastern Europe. Both buildings have been subject to threats of sanctions by the US to slow down and stop construction work.

Figure 5: Turkstream map



Sources: https://www.naturalgasworld.com/turkstream-41-laid-gazprom-56085

Figure 6: Nord Stream 2 Route



Sources: https://www.nord-stream2.com/en/pdf/document/125/

In addition to the construction of new pipelines, the Moscow government has in recent years decided to focus on marine gas transport: LNG. At present, Russia, in the field of LNG, is significantly behind as it has always focused on distributing gas in the European market. Today Moscow continues to be a step backwards compared to the large world exporters of LNG due to the lack of so-called technological know-how and specific equipment for liquefaction.

Putin, however, is not only strengthening and affirming its dominant position in Europe, but is also looking for new markets in the East: the goal is to build an integrated international network that combines TurkStream with the Power of Siberia. If this project comes into operation, Moscow will have the possibility to connect the various pipelines with the liquefaction terminal in Vladivostok. From where, LNG could be transported everywhere, thus making the Russian gas and LNG market global. Russia will then be able to sell liquefied gas to the highest bidder on the planet instead of being forced to sell only natural gas to the nearest countries (Soldatkin 2019).

Conclusion

To date, the situation in Europe is still completely uncertain, although Russia could emerge victorious from this clash with the United States in the coming years. The advantage that Putin has over the White House in the future is the dense network of alliances with strategic nations, as far as gas distribution is concerned. one on all of Erdogan's Turkey. The latter boasts several alliances with the main gas exporters in Europe, mainly with the states of North Africa (mainly Libya) and with Qatar (the alliance with Qatar, another historical supplier of natural gas of the Old Continent. This intertwining of alliances could lead Putin's Russia in the coming years to directly and indirectly control the main foreign gas outlets in Europe. However, the US and European counter offensives seem to lack strength. The various sanctions and visa blockades, mainly by the US, and to a lesser extent by Europe, do not seem at all to undermine the power of Gazprom and thus Russia itself. An example of successful US sanctions against Russian projects can be found in the termination of the Nord Stream 2 project on 22 December 2019. The success of these sanctions, however, has led to a tightening of relations between Washington and Berlin.

The only conclusion that can be given to date of this gas war, whoever will be the winner, the loser will always be one: Europe. Whatever happens, the old continent will always depend on a third nation that will always have the power (little or more will depend on the strength of the nation) to dictate the conditions of gas sales.

Bibliography

1. Austvik, O.G. "The EU Energy Union, Energy Security and Russian Gas." *Mossavar-Rahmani Center for Business & Government*, 2015.
2. Barlaam, R. *L'America vuole esportare il 50% di gas in più in Europa.* 9 Luglio 2019. https://www.ilsole24ore.com/art/l-america-vuole-esportare-50percento-gas-piu-europa-ACOPsaX.
3. Bessi, G. *House of zar. Geopolitica ed energia ai tempi di Putin e Trump.* 2019.
4. —. *Vi spiego la guerra fredda del gas tra Stati Uniti e Russia.* 15 Febbraio 2018. https://www.startmag.it/energia/guerra-gas-stati-uniti-russia/.
5. Bohi, D., Michael A. Toman, Margaret A. Walls. *The Economics of Energy Security.* Boston, 1996.
6. Cornot-Gandolphe, S. "The US natural gas exports. New rules on the European gas landscape." *Ifri*, 2016.
7. Dell'Olmo, G. *Geopolitica del gas naturale: la nuova frontiera dello scontro Russia-Usa.* 23 Maggio 2019. https://it.insideover.com/politica/geopolitica-gas-naturale-russia-stati-uniti.html.
8. Department of Energy & Climate Change. *Energy Markets Outlook.* London: The Stationery Office, 2009.
9. Ercoli, A. *La responsabilità dell'UE verso la geopolitica energetica della Russia.* 10 Marzo 2019. https://www.geopolitica.info/tag/geopolitica-del-gas/.
10. Grigas, A. *The New Geopolitics Of Natural Gas.* Londra, 2017.
11. Hogselius, P. *Red Gas: Russia and the Origins of European Energy Dependence.* New York: Palgrave macmillan, 2013.
12. IEA and KEEI. "LNG Market Trends and their implications." 2019.
13. International Energy Agency. *Towards a Sustainable Energy Future.* 2001.
14. Jun, E., Wonjoon K., Heung Chang S. "The Analysis of Security Cost for Different Energy Sources." *Applied Energy*, 2008.
15. Le Coq, C., Paltseva E. "Measuring the Security of External Energy Supply in the European Union." *Energy Policy*, 2009.
16. Lefèvre, N. "Measuring the Energy Security Implications of Fossil Fuel Resource Concentration." *Energy Policy*, 2009.

17. Lieb-Dóczy, E, Achim-Rüdiger B., MacKerron G. "Who Secures the Security of Supply? European Prospectives on Security, Competition and Liability?" *The Electricity Journal*, 2003.
18. Melchiorre, E. *La Politica Energetica russa.* Maggio 2006. https://economia.tesionline.it/economia/article.jsp?id=883.
19. Molnar, G., Arno B., Christian E., and Genovese F. "Europe's LNG Strategy in the Wider EU Gas Market." *CEPS Policy Brief*, 2015.
20. Muratore, A. *Las Guerra fredda del gas.* 12 Settembre 2019. http://osservatorioglobalizzazione.it/osservatorio/la-guerra-fredda-del-gas/.
21. Noel, P., Sachi F.*Gas Supply Security in the Baltic States: A Qualitative Assessment.* 2010.
22. Patterson, W. *Managing Energy Wrong.* 2008.
23. Pustišek, A., and Michael K. *Natural Gas: A Commercial Perspective.* Stuttgart: Springer, 2017.
24. Ruszel, M. "Natural gas supplies as an instrument of geopolitical conflict between the Russian Federation and Ukraine." *Polityka Energetyczna – Energy Policy Journal*, 2019.
25. Scheepers, M., A.J. Seebregts, J.J. de Jong, J.M. Maters. "EU Standards for Security of Supply." *Energy Research Center at the Netherlands*, 2007.
26. Smolinova, E. *Russia: La diplomazia del gas.* Pisa: Unoversità degli studi di Pisa, 2014.
27. Soldatkin, V. *Record Russian gas sales to Europe help Gazprom.* 2019. https://www.reuters.com/article/us-gazprom-results/record-russian-gas-sales-to-europe-help-gazprom-profits-double-idUSKCN1S51DU.
28. T.Klare, M. *Resource Wars: The New Landescape of Global Conflict.* New York: Henry Holt & Co, 2002.
29. The Economist. *The Nord Stream 2 gas pipeline is a Russian trap.* 19 Febbraio 2019. https://www.economist.com/leaders/2019/02/16/the-nord-stream-2-gas-pipeline-is-a-russian-trap.
30. *Why America struggles to sell LNG in Europe.* 16 Novembre 2018. https://www.economist.com/the-economist-explains/2018/11/16/why-america-struggles-to-sell-lng-in-europe.
31. The Oxford Institute for Energy Studies. "Russian LNG:Becoming a Global Force." *The Oxford Institute for Energy Studies*, 2019.
32. The Oxford Institute for Energy Studies. "Russia-Ukraine gas transit talks: risks for all sides." *The Oxford Institute for Energy Studies*, 2019.
33. Vicini, G., Francesco G., Anil M., Valeria C. "Security of Energy Supply: Comparing Scenarios from a European Prospective." *SSRN eLibrary*, 2005.
34. Vita, L. *La nuova guerra fredda che spacca l'Europa.* 13 Novembre 2019. https://it.insideover.com/politica/la-nuova-guerra-fredda-che-spacca-leuropa.html.
35. Winzer, C. *Conceptualizing Energy Security.* 2011.
36. Wright, P. "Liberalisation and the Security of Gas Supply in the UK." *Energy Policy*, 2005.

Valerio Tati, student of Political Economy at "La Sapienza" University of Rome, Faculty of Economics. His interests include economic development and geopolitical affairs.
ORCID: 0000-0001-5167-9349

ISSN: **2545-0859**