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Implementation of EU energy policy priorities in the Baltic Sea Region countries: Sustainability assessment based on neutrosophic MULTIMOORA method

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A B S T R A C T

The European Union (EU) has set ambitious goals for climate change and energy in its pursued policies (20% of renewable energy until 2020, 27% until 2030, and the aim to become the global leader in energy produced by renewable energy sources). Even more ambitious goals are established in the strategy of Energy 2050. Today European energy policy is oriented towards energy security, expansion of energy markets, energy efficiency, decarbonisation, and scientific research and innovations. The broader aim of this policy is a radical shift away from the current energy system to introduce a new system which would ensure environmental consistency, affordability of consumer prices, and security of supply. The paper analyses the trends of energy development across the eight Baltic Sea Region (BSR) countries. The analysis covers the period of 2008–2015. The main aim of the paper is to compare BSR countries achievements in sustainable energy development. The aggregate measures of energy sustainability are devised utilising multi-criteria decision-making (MCDM) MULTIMOORA (Multi-Objective Optimization on the basis of Ratio Analysis) technique. The paper presents an original framework for sustainable energy development indicators. The EU energy policy priorities govern the choice of indicators of energy sustainability. The comparative assessment of BSR countries, based on neutrosophic MULTIMOORA technique, by applying indicators from the framework, indicated that the best-performing countries regarding the achievement of EU sustainable energy development goals during the research period were Denmark and Latvia. The findings of this research can give useful information to energy policy decision makers.

1. Introduction

Sustainable growth (more efficient, environment-friendly and competitive economy) is one of the three priorities of the Europe 2020 Strategy. To achieve this priority, European Commission set the following targets: reduce greenhouse gas (GHG) emissions not less than 20% compared to 1990 levels; increase the share of renewable energy sources (RES) in final energy consumption to 20%; increase energy efficiency by 20%. These targets are set as the main in the EU Climate and Energy Policy, which pursues sustainability, competitiveness and security of energy supply (European Commission, 2011). Under the Renewable Energy Directive (2009/28/EC), European Union (EU) member states (MS) have also taken national targets for development the share of RES in their energy production. These targets vary, to reflect countries' different situation for RES production and ability to increase it in the future, for instance in Malta target of RES is 10%, target in Sweden is 49%.

The 2030 Climate and Energy framework was adopted in 2014, building on the 2020 Climate and Energy Package and setting additional targets for the year 2030: not less than 40% reduction in GHG emissions (from 1990 levels); not less than 27% share for RES in final energy consumption; not less than 27% energy efficiency improvement. The targets are also in line with the longer term perspective outlined in the Energy Roadmap 2050 developing a competitive decarbonised EU economy in 2050. The Energy Roadmap indicates that by 2050, the EU should reduce GHG emissions up till 80% compared to 1990 levels, steps to achieve this are 40% reduction by 2030 and 60% reduction by 2040 (European Commission, 2010a; 2014a). The energy combustion sector has the most significant potential for cutting GHG emissions. To reach ambition goals, the EU has to continue progress towards a low-carbon economy, where clean, efficient technologies and competitiveness play an essential role. When striving for such ambitious goals it is

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very important to monitor situation in every MS and each EU region.

The Baltic Sea Region (BSR) is the first macro region of the EU and includes eight EU countries such as Denmark, Finland, Germany, Poland, Sweden and the Baltic States countries and other neighbouring countries such as Norway, Russia. The primary focus of EU policy in the BSR is to connect and to raise the prosperity of the countries and to save the Baltic Sea. Sustainable energy development improves all these areas and is the primary factor in implementing EU energy policy priorities.

There is a lack of studies on how BSR countries achieve ES energy policy goals, therefore, *this paper* aims to compare BSR countries achievements in sustainable energy development. Seeking to achieve the aim of the paper *the main tasks are*:

- to analyse EU energy policy for the BSR;
- to define sustainable energy development indicators for comparative assessment according to EU energy policy priorities;
- to analyse sustainable energy development indicators in BSR countries;
- to develop and to apply multi-criteria assessment tool for ranking BSR regarding the achievement of EU energy policy objectives.

The paper applies a novel technique for ranking BSR countries in terms of the EU energy policy priorities. Analysis will determine which BSR countries are leaders in achieving ES energy policy goals and how situation changed during 2008–2015. Also reasons, which made an impact during the period of the research, will be determined.

In achieving sustainable development on EU level requires the careful use of resources, technology, fostering initiatives and strategic management at regional and national levels. It also requires to monitor the impact of selected policy and strategy to see whether it is furthering sustainable development or if it should be modified. It is essential to be able to measure a country's or region's state of development and to monitor progress towards achieved goals of sustainability (Streimikiene, 2007). The most frequently used approaches to measure country's or region's sustainability in the energy sector have been: multi-criteria decision-making (MCDM) techniques and life cycle assessment (LCA).

MCDM techniques are more and more popular in sustainable energy management and policies assessment. The MCDM techniques provide the possibility to solve problems linked to multiple objectives. Some methods based on weighted averages, outranking, priority setting, fuzzy principles and their combinations are used for energy management and planning decisions (Strantzali, Aravossis, 2016). Since the beginning of the modern MCDM discipline in the early 1960s many significant advances have been developed in MCDM field, which include new approaches and sophisticated algorithms (computing tools) (Jayaraman et al., 2015; Mardani et al., 2015; Mardani et al., 2017; Lee, Chang, 2018).

MCDM methods are increasingly being used to assess energy sustainability. And there is a huge growth each year. As for instance, Mirjat et al. (2018) used AHP (Analytical hierarchy process) method for planning electricity generation scenarios in Pakistan. Colak and Kaya (2017) prioritized renewable energy alternatives in Turkey by using an integrated fuzzy MCDM technique, which combines AHP and fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solutions) methods. Lee and Chang (2018) assessed alternatives of renewable energy sources in Taiwan by using four MCDM methods – WSM (Weighted Sum Model), VIKOR (Multi-Criteria Optimization and Compromise Solution), TOPSIS and ELECTRE (Elimination and Choice Transcribing Reality). Al Garni et al. (2016) used AHP method for renewable power generation sources evaluation in Saudi Arabia. Erdogan and Sayin (2018) created a Hybrid MCDM Method, which integrates SWARA (Step-Wise Weight Assessment Ratio Analysis) and MULTIMOORA methods for selection of the most suitable fuel alternative. In this research an original neutrosophic MULTIMOORA technique is applied. The neutrosophic MULTIMOORA technique, proposed by Zavadskas et al. (2017) allows to deal explicitly with the uncertainty of the initial information.

In the next paragraphs of the paper, the EU energy policy for the Baltic Sea Region is presented, sustainable energy development indicators for comparative assessment according to the EU energy policy priorities are selected, and comparative assessment, based on neutrosophic MULTIMOORA technique is applied.

2. The EU energy policy for the BSR

2.1. Energy policy context

Sustainable energy development is a crucial principle in the European energy policy. RES development in the EU gives an opportunity to create a competitive, secure and sustainable energy sector and to solve the most urgent energy issues and challenges facing each EU country, such as reduce dependence on imports of energy, increase security in the energy supply, to achieve goals for reducing GHG emissions and protect the environment (Pacesilaa et al., 2016).

Reduce dependence of MS on imports of energy, especially dependency on natural gas and oil. The growing needs for energy increase natural gas, coal and oil imports from countries, which have large amounts of resources (such as Russia, Azerbaijan, Angola, Algeria and others), this fact involves economic and political costs (possibility of instability and risk). EU MS are reliant on the import of energy sources: 54% of the EU gross inland energy consumption in 2015 were imported energy. The EU imports of primary energy exceeded exports of more than 900 Mtoe in 2015. The largest net importers of energy were EU MS with the highest population, except Poland (because of reserves of coal remain). According to population size, the largest net importers were Belgium, Luxembourg and Malta in 2015. The security of the EU's primary energy supplies may be threatened because the most significant proportion of imports are concentrated in the hands of the few import partners. 65% of the EU imports of natural gas came from Russia, Norway and Algeria in 2015. Statistical data shows that 61% of EU solid fuel imports are from Russia, Columbia and the United States. Dependency on energy imports increased from 40% in 1990 to 54% by 2015 of gross energy consumption (Eurostat, 2018).

Increase security in the energy supply. Imported energy proportion has generally been rising in the EU over recent three decades. Consequently, security of energy supply is one of the most significant factors in strengthening the EU stability. The most significant part of the energy imported into the EU comes from Russia, which does not have proper political relationships with transit countries, especially in recent years. The energy security can be increased by the new measures for energy markets that were designed (oil, gas and electricity) to prevent and mitigate the consequences of potential disruptions to supplies.

One of the initiatives is called ENERGY 2020; it is a strategy for sustainable, competitive and secure energy. ENERGY 2020 defines energy priorities for a 10 years' period and puts forward actions that can be taken to solve different challenges: achieving an internal market with secure supplies and competitive prices; increase technological achievements; and effectively interact with supply partners (European Commission, 2010b).

Another initiative is international organisation the Energy Community establishment in 2005, which brings together the EU and its neighbouring countries on purpose to create an integrated European energy market. The primary objective of the organisation is to extend the EU internal energy market rules and principles to countries in the Black Sea region and South East Europe. Currently, the Energy Community has 9 contracting parties (Energy Community Secretariat, 2016). A vital role play diversity of suppliers, the mix of energy sources and energy transport routes in securing energy supplies. There are a lot of ongoing initiatives to develop electricity corridors, gas pipelines between Europe and its neighbours (eastern and southern). For example, Infrastructure Transparency Platform (PLIMA) is an integral part of building a strong electricity transmission corridor between east and west Europe; Gas Interconnection Bulgaria – Serbia (IBS) is a project which includes the construction of a 150 km long pipeline which connects the gas transmission networks of the two countries. Bulgaria-Serbia interconnector makes possible gas supplies to Serbia from new sources such as the Turkish stream and Southern Gas Corridor. The Southern Gas Corridor provides the transportation of gas from the Caspian region to the European countries through Turkey and Georgia and is one of the priority energy projects in EU energy policy.

In 2014 Energy Security Strategy was adopted. The Energy Security Strategy seeks to ensure safe energy supply for the European economy. The most actual issue of energy security is the strong dependence on a single supplier of energy source (non-EU). This security aspect is especially important for gas, but also crucial for electricity too. Three Baltic States are dependent on one external supplier of their electricity network (for the operation and balancing). The electric power interconnection between Poland and Lithuania (LitPol Link) is on top of the agenda for the Baltic States currently. In long-term the Energy Security Strategy proposes actions in five main areas: 1) to increase energy efficiency to reach the 2030 energy and climate policy goals; demand management through information and transparency (billing information, smart meters); 2) to finalize the internal energy market and to develop indispensable interconnections to respond to supply disruptions; 3) to increase energy production in the EU and to diversify suppliers and energy routes; 4) to use the information exchange mechanism with the European Commission about planned agreements with third countries which could have influence to security of energy supply; 5) to strengthen emergency and internal market unity mechanisms and to protect essential infrastructure (European Commission, 2014b). Table 1 shows indicators for monitoring progress of energy import dependency and energy security in the EU.

Net import dependency rate shows how much country is dependent on energy import to meet own energy needs. All MS were net importers of energy in 2016, the import dependency rate, also the change in the last decade, considerably varies across MS.

Aggregate supplier concentration index (from extra-European Economic Area (EEA) suppliers) shows how much energy is supplied from outside the EEA countries. Smaller values of supplier concentration index indicate more substantial diversification, and accordingly, it can be seen as a representative for lower risk to energy supply crisis, while bigger values of supplier concentration index indicate the low diversification of energy sources and, accordingly, bigger risk in the case of energy supply crisis. For the EU28 aggregate supplier concentration index is quite low, it indicates the diversification of imported sources in the region. Looking at individual MS, the level of the index varies from less than 10 to more than 60. Countries, which feature of sizeable local energy production like Denmark and UK and countries, which mostly rely on imports from EEA countries like Luxembourg or countries with a relatively low share of natural gas, oil and coal in their energy mix and many different suppliers like France have the low index. While in a few MS mostly which depend on suppliers from Russia like Bulgaria, Estonia, Finland index is very high (more than 50). The level of the aggregate supplier concentration index in Cyprus and Malta was 0 in 2016 because Malta imported no fossil fuels while Cyprus imported some sources but the energy was supplied from the EU internal market.

The N-1 rule for gas specifies adequacy of gas infrastructure. It

Table 1
Indicators for monitoring progress of energy import dependency and energy security in the EU.
Source: European Commission, 2018; Eurostat database, 2018.

Unit	Net import dependency rate		Concentration index of supplier		N-1 rule for gas	
	Net imports[a]	Absolute change, %	Aggregate supplier concentration index, 0–100[b]	Absolute change, 0–100	% of total demand[c]	Absolute change,%
Country	2016	Change 2005–2016	2016	Change 2005–2016	2016	Change 2009–2016
EU28	53.61	1.46	10.7	2.6	NA	NA
AT	62.45	− 9.52	30.48	7.68	232.57	87.57
BE	75.99	− 4.13	14.89	− 2.55	279	82
BG	37.17	− 9.52	60.25	5.98	50.6	21.6
HR	47.8	− 4.7	12.57	− 22.34	100.6	NA
CY	96.18	− 4.49	0	− 1.44	NA	NA
CZ	32.76	4.94	32.56	6.86	373.5	226.5
DK	13.94	63.96	5.8	1.5	135	62
EE	6.81	− 19.28	59.42	− 13.5	104.5	− 39.5
FI	45.26	− 8.89	67.24	4.12	129.1	129.1
FR	47.06	− 4.51	8.48	1.34	131	28
DE	63.49	2.97	25.13	13.59	197	− 48
EL	73.65	5.06	40.33	0.99	108.8	− 126.2
HU	55.59	− 6.38	57	11.34	129	48
IE	69.06	− 20.62	6.48	2.67	134	116
IT	77.54	− 5.84	16.08	0.45	105.5	− 18.5
LV	47.19	− 16.67	30.41	− 18.56	220.67	57.67
LT	77.44	20.66	51.51	− 44.99	117	60
LU	96.12	− 1.3	2.72	− 24.86	NA	NA
MT	100.85	0.85	0	0	NA	NA
NL	45.2	7.41	25.63	14.7	198	33
PL	30.29	13.07	25.73	− 0.05	133.91	− 0.09
PT	73.52	− 15.06	29.92	8.66	110	5
RO	22.3	− 5.35	19.89	1.02	100.7	5.7
SK	59.01	− 6.3	66.08	− 8.33	305.2	187.2
SI	48.37	− 4.1	25.73	− 4.29	57.4	− 17.6
ES	71.91	− 9.52	18.31	5.07	132	8
SE	31.93	− 5.05	21.86	6.86	15	5
UK	35.3	21.92	1.39	− 1.26	140	26

[a] % of gross inland consumption and international bunkers.
[b] 100 means maximum concentration.
[c] % of energy needs that can be fulfilled if the largest item of gas supply infrastructure is disrupted.

indicates the ability of gas infrastructure to satisfy the total gas needs in the event of a disruption of the single largest gas infrastructure item during days of exceptionally high demand (e.g. freezing days). It is expressed as the percentage of total demand that can be satisfied with the remaining gas infrastructure. From all energy sources, natural gas is the one which generates most concern about the security of supply (European Commission, 2017a). Based on the security of gas supply requirements all MS have to guarantee / to solve the situation if the single most substantial gas infrastructure fails, the capacity of the still existing infrastructure can satisfy total energy needs. This condition is met if indicator reaches at least 100%. In 2016 only few MS had the indicator value of less than 100%: Bulgaria, Slovenia, Sweden and Luxembourg (latest data of Luxembourg available only in 2015, where the indicator was 78,1%).

Meet goals for reducing GHG emissions and protect the environment. The main cause of carbon dioxide released into the atmosphere are the fossil fuel combustion and the energy sector is the main contributor to GHG emissions in Europe and the BSR as well. The increase of use of RES and energy efficiency are the main ways to achieve GHG emission reduction in energy combustion sector. The EU is seeking to implement to get at least 20% of its final energy consumption from RES by 2020, and at least 27% by 2030. The Renewable Energy Directive (2009/28/EC) sets national targets for all MS, taking into account their different starting points. EU MS are free to determine how they support RES, so long as they comply with the rules of the EU energy market. The most widespread support mechanism for RES in electricity sector have been feed-in tariffs, competitive auctions and feed-in premiums. Table 2 shows indicators for monitoring progress of energy efficiency and decarbonisation of the economy in the EU.

To reduce GHG emissions is another principal objective of the EU energy policy. The EU has set ambitious objectives to decarbonise its economy and cut GHG emissions at least 80% by 2050. Scientific studies show that reaching such reductions requires enormous structural changes to energy systems (OECD/IEA, IRENA, 2017; Spencer et al., 2015; Bataille et al., 2016; Spencer et al., 2017). Now the mid-term target is to reduce GHG emissions by at least 20% compared to 1990 levels by 2020 is reached. The critical policy tools to achieve the GHG target are the EU Emissions Trading System and the Effort Sharing Decision. By 2015, the EU cut GHG emissions by 22% compared with 1990 level (Eurostat, 2018). In 2016, the European Commission presented a new package The Clean Energy For All Europeans (European Commission, 2016a) of measures with the goal of providing the stable legislative framework, which includes fully updated model-based energy scenarios involving deep emission reductions and legislative action to foster energy transition to 2030.

The EU has set energy efficiency target and has adopted various measures improving energy savings in the EU, such as: to reduce national energy sales 1.5% each year; buildings owned by governments should be renovated in energy efficient way not less than 3% each year; mandatory energy efficiency certificates of buildings; energy efficiency standards and labelling for products; each EU MS must prepare action plan for energy efficiency each 3 years; development of smart meters for electricity and gas; large companies carry out energy consumption audit each 4 years; secure consumers rights to have free access to information; the European Commission has announced recommendations for improving practice in energy savings. In 2016 the European Commission proposed an update to the Energy Efficiency Directive (2016/0376 (COD)), which include 30% energy savings target for 2030, and measures to ensure and to monitor progress (European Commission, 2016b).

Table 2
Indicators for monitoring progress of decarbonisation of the EU economy.
Source: European Commission, 2018.

Unit	Primary energy consumption		Final energy consumption		GHG emissions reductions		Renewable energy share	
Country	2016, Mtoe	Absolute change 2005–2016, %	2016, Mtoe	Absolute change 2005–2016, %	Relative change 1990 & 2016, %	Gap between GHG projections and 2020 target[a], %	2016, %	Gap to 2020 target[b], %
EU28	1542.74	− 9.95	1107.66	− 7.13	− 22.62	− 6.77	17.04	2.96
AT	31.84	− 1.52	28.13	1.33	2.34	2.45	33.49	0.51
BE	48.99	− 4.56	36.33	− 0.68	− 17.74	3.48	8.65	4.35
BG	17.63	− 6.73	9.66	− 5.13	− 43.53	− 21.71	18.81	− 2.81
HR	8.07	− 11.40	6.64	− 8.26	− 27.55	− 23.50	28.22	− 8.22
CY	2.40	− 2.55	1.76	− 4.09	50.91	− 9.49	9.35	3.65
CZ	39.94	− 5.97	24.75	− 6.00	− 36.21	− 8.52	14.89	− 1.89
DK	17.17	− 10.75	14.45	− 6.77	− 27.41	− 2.31	32.18	− 2.18
EE	6.13	13.81	2.82	− 2.08	− 52.20	− 0.28	28.81	− 3.81
FI	33.06	− 0.88	25.25	0.25	− 15.99	0.75	38.70	− 0.70
FR	235.40	− 9.53	147.16	− 8.46	− 13.52	− 6.09	15.98	7.02
DE	295.84	− 6.75	216.45	− 0.92	− 26.36	3.26	14.82	3.18
EL	23.55	− 23.17	16.69	− 20.35	− 9.03	− 17.78	15.21	2.79
HU	23.86	− 8.04	17.87	− 4.71	− 34.21	− 28.55	14.19	− 1.19
IE	14.58	− 1.00	11.61	− 8.18	13.38	16.96	9.49	6.51
IT	148.44	− 18.20	115.93	− 15.47	− 15.19	− 8.47	17.41	− 0.41
LV	4.29	− 4.61	3.82	− 4.93	− 56.69	− 9.18	37.16	2.84
LT	5.99	− 24.93	5.11	9.36	− 59.91	− 12.59	25.58	− 2.58
LU	4.16	− 12.76	4.04	− 9.74	− 12.98	2.61	5.44	5.56
MT	0.72	− 21.72	0.58	25.86	− 11.40	11.46	6.05	3.95
NL	64.85	− 5.77	49.52	− 8.26	− 7.84	− 10.02	5.97	8.03
PL	94.32	7.61	66.65	13.99	− 16.10	− 8.39	11.29	3.71
PT	22.12	− 11.14	16.11	− 15.25	13.94	− 17.62	28.50	2.50
RO	31.26	− 14.92	22.28	− 9.85	− 53.88	− 17.60	25.03	− 1.03
SK	15.53	− 12.49	10.42	− 9.89	− 44.78	− 25.24	11.99	2.01
SI	6.67	− 4.95	4.88	− 0.43	− 5.63	− 13.33	21.29	3.71
ES	117.24	− 13.72	82.50	− 15.62	15.68	− 9.88	17.26	2.74
SE	47.05	− 3.44	32.58	− 3.23	− 23.54	− 14.78	53.82	− 4.82
UK	181.66	− 18.47	133.69	− 12.48	− 37.37	− 9.93	9.28	5.72

[a] % of 2005 base year emissions.
[b] data > 0 means exceeded goal.

2.2. The EU energy policy implementation in the BSR

The EU MS involved in the Baltic Sea Region (BSR) are Denmark, Finland, Germany, Poland Sweden and the Baltic States countries (85 million people - 17% of EU population) and the EU neighbouring countries such as Russia, Norway. The EU Strategy for the Baltic Sea Region (EUSBSR) is the first macro-regional strategy in Europe. The EUSBSR was approved in 2009, and it is an agreement between the MS of the EU and the European Commission to support cooperation between the countries bordering the Baltic Sea to meet the common challenges and to benefit from the same opportunities facing the region. The EUSBSR contains a strong focus on energy and climate. The Strategy contains three pillars: save the sea, increase prosperity and connect the region. Targets and indicators of the Strategy are entirely in line with and contribute to the objectives of Europe 2020 Strategy (European Commission, 2017b). The implementation of the EUSBSR takes place in joint MS projects and processes. The projects and processes demonstrating the progress of the EUSBSR are called Flagships. Under the policy area of energy there are two types of projects that seek to connect the region (infrastructure, internal market, security of supply, synchronisation), to improve the efficiency of energy markets, and increase prosperity (increase the use of RES, promote energy savings).

Building on the lessons learnt and experience from the EUSBSR other strategies to boost the regional development was proposed: of the Danube Region in 2010, the Adriatic and Ionian region in 2014, the Alpine Region in 2015.

Launched in 2009, the Baltic Energy Market Interconnection Plan (BEMIP) forms part of the EUSBSR. Based on the principles of sustainability, competitiveness and security, the BEMIP upholds the critical objectives proposed by the Energy Union – security of supply (i.e. diversification of supply routes), market integration (removal of technical/regulatory barriers), energy efficiency, decarbonisation, and research and innovation. The BEMIP coordinates the projects involving all BSR countries for the gas and electricity internal market, electricity interconnections between countries, new electricity generation capacity development and diversification of gas supplier's development.

Connecting the power systems of Estonia, Latvia and Lithuania to the EU internal market is one of the critical priorities of the BEMIP. The European Energy Security Strategy (EESS) involves more than 30 energy infrastructure projects which are very important to ensure energy security in the EU and 12 of them are located in the BEMIP region: 5 electricity projects and 7 gas projects (European Commission, 2014c). Some of these projects today have already been completed (e.g. LNG vessel in Klaipeda), some are in progress (e.g. synchronisation of the Baltic States with the continental European networks).

There are more than 2000 inhabited islands in the EU, and many of them depend on fossil fuel imports, although they have access to renewable sources of energy, such as solar, wind and wave energy. In 2017 the European Commission, together with 14 EU countries, where 5 of them are BSR countries (Denmark, Estonia, Finland, Germany and Sweden) signed a political declaration to launch the new Clean Energy for EU Islands initiative. The initiative is as part of the Clean Energy for All Europeans package of proposals in 2016.

Under the Effort Sharing Decision, MS are required to limit their GHG emissions. The target for each MS was approved by the EU Climate Change Committee in 2012. Increase use of RES and improvement in energy efficiency are the main ways to achieve GHG emission reduction targets for BSR countries. The Renewable Energy Directive (2009/28/EC) specifies national renewable energy targets for each MS. Each EU country has different energy resources and specific energy market. In addition to reaching the EU's energy savings target by 2020 and for 2030, each EU MS have set their own energy savings targets, this is required in the Energy Efficiency Directive (2012/27/EU).

In Table 3 the national energy targets and their implementation in the BSR countries, based on the EU policy targets are presented.

Table 3
National energy targets and their implementation in the BSR countries, based on the EU policy targets, 2015.
Source: Eurostat database, 2018.

BSR countries	Reduction of GHG emissions				Increase the share of RES			Increase in energy efficiency					
	Target, %	Target, Mtoe	2015, Mtoe	Progress (+/−), Mtoe	Target, %	2015, %	Implementation, %	Primary energy Target, Mtoe	2015, Mtoe	Progress (+/−), Mtoe	Final energy Target, Mtoe	2015, Mtoe	Progress (+/−), Mtoe
EU28	− 20	2618.17	2519.23	98.94	20	17	85	1483	1529.6	− 46.6	1086	1082.2	3.8
DK	− 20	32.06	32.52	− 0.46	30	31	103	17.4	16.5	0.9	14.4	13.9	0.5
EE	11	6.02	6.14	− 0.12	25	29	116	6.5	6.2	0.3	2.8	2.8	0.0
FI	− 16	28.36	29.89	− 1.53	38	39	103	35.9	32	3.9	26.7	24.2	2.5
DE	− 14	410.91	444.08	− 33.17	18	15	83	276.6	292.9	− 16.3	194.3	212.1	− 17.8
LV	17	9.99	9.01	0.98	40	38	95	5.4	4.3	1.1	4.5	3.8	0.7
LT	15	15.24	13.25	1.99	23	26	113	6.5	5.8	0.7	4.3	4.9	− 0.6
PL	14	205.18	186.77	18.41	15	12	80	96.4	90	6.4	71.6	62.3	9.3
SE	− 17	36.08	33.90	2.18	49	54	110	43.4	43.7	− 0.3	30.3	31.8	− 1.5

The Eurostat (The Statistical Office of the European Communities) has the responsibility to give statistical information to European institutions, by favouring the harmonisation of statistical methods across MS. Latest available data highlight that the portion of RES grew significantly in many MS. Among the BSR countries, five countries of eight have already reached their 2020 target (Denmark, Estonia, Finland, Lithuania and Sweden) in 2015. However, it does not mean that these countries have a higher value in the share of RESs, because targets vary, to reflect countries' different situation and ability to increase it (Table 3).

Regarding reducing GHG emissions half of BSR countries have reached 2020 target (Lithuania, Latvia, Poland and Sweden). However, it's necessary to be noted, that the target for Lithuania, Latvia and Poland compared to 1990 level was respectively 17%, 15% and 14% bigger than 1990 level. Targets of energy efficiency are fulfilled by Denmark, Estonia, Finland, Latvia and Poland in 2015. In the next paragraph of the paper sustainable energy development indicators are selected, and comparative assessment of achievements in sustainable energy development of BSR countries, based on multi-criteria assessment tool is presented in the period 2008–2015.

3. Comparative assessment of sustainable energy development in BSR countries

3.1. Sustainable energy development indicators for comparative assessment according to the EU energy policy priorities

There has been an enormous amount of initiatives in the past three decades to assess sustainable energy development (Iddrisu and Bhattacharyya, 2015; Hirschberg et al., 2007; World Economic Forum, 2015; RSC project, 2016; OECD, 2013a; OECD, 2013b; Eurostat, 2018; OECD, 2004; OECD, 2013a; OECD, 2013b; OECD/NEA, 2002; Brown and Sovacool, 2007; Burgherr et al., 2005; Streimikiene and Sivickas, 2008; Zelazna and Golebiowska, 2015; Streimikiene and Siksnelyte, 2016; Streimikiene et al., 2018; Sartori et al., 2017 and others), both at an international and national level. The indicators are taken together and in context, allowing for specific characteristics between countries, give a pretty comprehensive picture of a country's energy system. When indicators change over time, they are characteristics of progress and policy implementation level. These indicators guide policymakers to evaluate the effectiveness of the support mechanisms, to assess progress and helps to guide decisions on investments in the energy sector, and pollution control.

International Atomic Energy Agency (IAEA) with United Nations Department of Economic and Social Affairs (UNDESA), the International Energy Agency (IEA), the European Environment Agency (EEA) and Eurostat introduced a set of sustainable development indicators in the energy sector. There are 30 indicators, which are classified into economic, social and environmental dimensions. These dimensions are grouped into 7 themes and 19 sub-themes. There are indicators, which could be classified in more than one dimension, theme, sub-theme, given the numerous interlinkages among indicators (IAEA, 2005). Table 4 presents the structure of Energy Indicators for Sustainable Development (EISD).

The indicators in this research were selected based on the availability and reliability of data and seeking to define sustainable energy development goals according to EU energy policy priorities. Table 5 provides a summary of the indicator set used in this research.

The implementation level of the target has been selected to reflect countries' different situation and ability to achieve the sustainable energy goals. 4 environmental indicators define implementation level of the EU energy policy priorities (reduce GHG emissions, increase the portion of RES, increase in energy savings). Also, there are involved 5 economic indicators for monitoring progress of energy security in the EU, which is an issue of sustainable energy development in the region and a part of energy policy in the EU: net import independence (it is an inverse of net import dependency), supplier concentration and main entities market share. 5 social indicators were selected to reflect on critical social issues of sustainable energy development.

Table 4
The structure of EISD.
Source: IAEA, 2005.

SOCIAL	ECONOMIC	ENVIRONMENTAL
Equity • Energy accessibility • Energy affordability • Disparities Health • Safety	Use and Production Patterns • Overall energy use • Overall energy productivity • The efficiency of energy supply • Energy production • End-Use • Diversification of energy (Fuel Mix) • Energy prices Security • Import of energy • Strategic fuel stock	Atmosphere • Climate Change • Air Quality Water • Water Quality Land • Soil Quality • Forest • Solid Waste Generation and Management

Table 6 presents achievements in sustainable energy development in BSR countries in 2008:

Table 7 presents achievements in sustainable energy development in BSR countries in 2015.

3.2. Multi-criteria assessment tool

The applied method is governed by the synthesis of the neutrosophic sets (Smarandache, 1999) and traditional MULTIMOORA approach proposed by Brauers and Zavadskas (2010). In the beginning, the aggregated decision matrix X is constructed as it is usually done in the multicriteria decision making framework. The x_{ij} elements correspond to i^{th} criteria of $j^{\underline{th}}$ alternative. Therefore, this matrix is constructed as follows:

$$X = \begin{bmatrix} x_{11} \cdots x_{1m} \\ x_{n1} \cdots x_{nm} \end{bmatrix} \tag{1}$$

At the beginning of the neutrosophic MULTIMOORA method is need to compose the ratio system. In the first step, by vector normalisation approach is applied for the normalisation of the aggregated decision matrix:

$$X^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{2}$$

After normalisation, At the neutrosophication step, the crisp values of the decision matrix are converted into single-valued neutrosophic members by the transformation rules, which are presented at Zavadskas et al. (2017).

By this step, the aggregated decision matrix is presented in the neutrosophic form. Therefore, the first objective of neutrosophic aggregative MULTIMOORA approach will have the following expression:

$$Q_j = \sum_{i=1}^{g} w_i (x_n^*)_{ij} + \left(\sum_{i=g+1}^{n} w_i (x_n^*)_{ij} \right)^c \tag{3}$$

where g elements are expressing the members of the maximised criteria, and n-g components correspond to the minimised criteria. Traditionally, single-valued neutrosophic members have the following structure:

$$(x_n^*)_1 = (t_{n1}, i_{n1}, f_{n1}) \tag{4}$$

The details of the structure are provided in an original paper by Peng et al. (2014). The details concerning the operations over single-valued neutrosophic numbers are referred to Zavadskas et al. (2017).

Table 5
Set of the EISD for BSR countries assessment.

Impact area	Code	Indicator	Units of measurement	Target value	Significance
Economic indicators (1/3)					
Use and Production Patterns	EC1	Overall use	Energy per Capita - kg/cap	-	1/7
	EC2	Energy productivity	Total primary energy use/ unit of GDP	-	1/7
	EC3	Energy intensity	Primary energy intensity - toe/M€'10 7	-	1/7
	EC4	Supply efficiency	Distribution losses, % of generated energy	-	1/7
Security	EC5	Energy independence	Import independency - %	+	1/7
	EC6	Supplier concentration: electricity	Cumulative market share generation, Main entities - %	-	1/7
	EC7	Supplier concentration: gas	Cumulative market share, Main entities - %	-	1/7
Σ					**1.00**
Environmental indicators (1/3)					
Atmosphere	EN1	Reduce GHG emissions, in ESD sectors	Target implementation, %	+	1/5
	EN2	Increase the share of RES in final energy consumption	Target implementation, %	+	1/5
	EN3	Increase in energy efficiency, consumption: primary energy	Target implementation, %	+	1/5
	EN4	Increase in energy efficiency, consumption: final energy	Target implementation, %	+	1/5
Land	EN5	Energy consumption (waste (non-RES))	% of gross inland consumption	+	1/5
Σ					**1.00**
Social indicators (1/3)					
Equity	SO1	Affordability of electricity: households	Price, EUR	-	1/5
	SO2	Affordability of gas: households	Price, EUR	-	1/5
	SO3	Opportunity to choose: gas	Electricity retailers to final consumers –Nr, the base year 2005	+	1/5
	SO4	Opportunity to choose: electricity	Gas retailers to final Consumers –Nr, the base year 2005	+	1/5
Health	SO5	CO2 per capita - kg CO2/cap	CO2 per capita - kg CO2/cap	-	1/5
Σ					**1.00**

Table 6
The EISD in BSR countries, 2008.

	DK	DE	EE	LV	LT	PL	FI	SE
EC1	3 593.6	4 101.2	4 441.0	2 141.6	2 888.3	2 568.3	6 787.7	5 369.3
EC2	0.080	0.123	0.347	0.188	0.249	0.253	0.179	0.133
EC3	77.346	119.8	339.8	212.0	251.8	273.1	175.3	127.9
EC4	5.115	1.910	5.838	3.997	4593	2.952	3.218	3.618
EC5	120.470	39.059	75.291	41.188	42.218	69.751	45.904	62.943
EC6	78	72	96.5	93	87.6	45.9	63	80
EC7	100	89	100	100	99.5	96.2	100	100
EN1	78.135	86.489	92.691	109.409	114.108	107.432	85.338	88.83
EN2	62	47.778	75.6	74.5	77.391	51.333	82.368	92.449
EN3	88.506	86.262	112.308	114.815	73.846	103.734	103.343	91.705
EN4	92.361	88.008	89.286	106.667	81.395	112.849	103.745	93.069
EN5	2.266	0.985	0	0.107	0	0.246	0.322	0.88
SO1	0.264	0.215	0.081	0.084	0.086	0.126	0.122	0.17
SO2	0.096	0.064	0.034	0.031	0.033	0.042	0.033	0.093
SO3	3.2	1	1.304	1	1.2	1.018	1	0.857
SO4	0.514	1	0.925	1	1.143	0.517	1	0.926
SO5	9946.3	10,687.1	13,415.6	3871.6	4765.4	8630.6	11,408.8	5801.7

For the construction of the second objective, the deviation from the reference point applying Min-Max Norm of Tchebycheff is considered:

$$\min_j \left(\max_i |D(r_i - w_i(x_n^*)_{ij}) \underset{i}{|} \right) \tag{5}$$

The reference point can be expressed as follows:

$$r_i = (1.0; 0.0; 0.0) \tag{6}$$

for the case of the maximised criteria and in the case of the minimised criteria:

$$r_i = (0.0; 1.0; 1.0) \tag{7}$$

The following score function is applied to the relating the neutrosophic members as follows:

$$S((x_n^*)_1) = \frac{3 + t_{n1} - 2i_{n1} - f_{n1}}{4} \tag{8}$$

For the estimation of the distance between two single-valued neutrosophic members the following function is applied:

$$D((x_n^*)_1, (x_n^*)_2) = \sqrt{\frac{1}{3}((t_{n1} - t_{n2})^2 + (i_{n1} - i_{n2})^2 + (f_{n1} - f_{n2})^2)} \tag{9}$$

At the last step of the neutrosophic MULTIMOORA method, the third objective is constructed by Full Multiplicities form which includes maximised criteria as well as minimised ones expressed by the purely multiplicative utility function. In this case, the overall utility for each considered alternative can be expressed by the following equation:

$$U_j = \frac{S\ (A_j)}{S\ (B_j)} \tag{10}$$

Table 7
The EISD in BSR countries, 2015.

	DK	DE	EE	LV	LT	PL	FI	SE
EC1	2962.3	3869.6	4757.1	2205.3	2366.4	2511.1	6059.3	4665.2
EC2	0.061	0.097	0.304	0.175	0.155	0.209	0.152	0.098
EC3	64.125	105	352.4	201.4	172.3	214.4	170.8	107
EC4	5.514	1.801	4.702	3.274	3.861	2.469	2.717	2.374
EC5	86.875	38.088	92.619	48.845	21.562	70.696	53.182	69.886
EC6	44	76	79.8	57.4	63.2	25.5	62.8	73.4
EC7	100	80.3	100	100	93.1	82.5	100	100
EN1	98.565	91.928	98.007	109.81	113.058	108.973	95.16	106.042
EN2	102.667	81.111	114.4	94	112.174	78.667	103.421	110
EN3	105.172	94.107	104.615	120.37	110.769	106.639	110.864	99.309
EN4	103.472	90.839	100	115.556	86.047	112.989	109.363	95.05
EN5	2.547	1.353	1.071	1.256	0.333	0.548	0.721	1.37
SO1	0.307	0.295	0.13	0.164	0.126	0.144	0.155	0.185
SO2	0.08	0.068	0.046	0.05	0.042	0.05	0.054	0.113
SO3	3.4	1.351	0.913	4	0.8	1.544	0.767	1
SO4	0.7	1.318	1.15	1	2.429	0.506	1	0.967
SO5	6746.8	10,054.1	12,137.4	3817.9	4582.6	8222.8	8479.3	4 669.0

Here A_j and B_j components are calculated as:

$$A_j = \prod_{i=1}^{g} w_i(x_n^*)_{ij},\ B_j = \prod_{j=g+1}^{n} w_i(x_n^*)_{ij} \tag{11}$$

The first component A_j symbolises the product of maximised criteria of j[th] alternative. In the same way, the second component B_j symbolises product of minimised criteria of the same alternative. All three objectives are finally summarised by the dominance theory (Brauers and Zavadskas, 2011).

3.3. Multi-criteria assessment of BSR countries in achieving sustainable energy development goals

The results of the first objective in neutrosophic MULTIMOORA method: neutrosophic ratio system for the countries are shown in Tables 8 and 12.

The second objective of neutrosophic MULTIMOORA method: the neutrosophic reference point for the examined countries provides the results which are shown in Tables 9 and 13.

The third objective of neutrosophic MULTIMOORA method: neutrosophic full multiplicative form for the studied countries can be evaluated by the results of Tables 10and 14.

The dominance theory was applied to obtain the overall evaluation by all neutrosophic MULTIMOORA approach objectives, and these results are presented in Tables 11, 15.

In comparing BSR countries achievements in sustainable energy development Denmark and Latvia are the leading countries: in 2008, Denmark was ranked first, leaving Latvia in the second place (Table 16). These two countries exchanged positions in 2015. Poland dropped in rank from the third to the sixth, Sweden from the fourth to the fifth, whereas Finland from the sixth to the seventh place during the period considered. Germany, which was the fifth in rank among the BSR countries in 2008, took the last place in 2015, while Lithuania and Estonia made the most significant progress during the period considered: Lithuania rose in rank from the seventh to the third place, while Estonia from the eighth to the fourth position in the ranking.

Each country is discussed separately to assess the progress of BSR countries in achieving sustainable energy development goals.

Denmark. Denmark, as well as Latvia, were the leaders concerning sustainable energy development and the implementation of EU energy policy objectives. Although Denmark consistently and systematically

Table 8
The neutrosophic ratio system objective for the examined countries, 2008.

	Q_i	$S(Q_i)$	Rank
DK	(0.8497 0.1451 0.1493)	0.8526	4
DE	(0.8571 0.1452 0.1676)	0.8498	5
EE	(0.8092 0.1988 0.2056)	0.8015	8
LV	(0.8980 0.1043 0.1264)	0.8908	1
LT	(0.8801 0.1214 0.1462)	0.8728	2
PL	(0.8775 0.1234 0.1475)	0.8708	3
FI	(0.8378 0.1659 0.1798)	0.8315	7
SE	(0.8422 0.1611 0.1781)	0.8355	6

Table 9
The neutrosophic reference point objective for the countries, 2008.

	$\max\lvert D(r_i - w_i(x_n^*)_{ij})\rvert$	Rank
DK	0.9865	1–2
DE	0.9901	3
EE	0.9997	7–8
LV	0.9973	6
LT	0.9997	7–8
PL	0.9935	5
FI	0.9917	4
SE	0.9865	1–2

Table 10
The neutrosophic full multiplicative form objective for the countries, 2008.

	$S(A_j)$	$S(B_j)$	U_j	Rank
DK	0.3156×10^{-16}	0.0380×10^{-15}	0.82990	1
DE	0.0014×10^{-16}	0.0153×10^{-15}	0.00945	5
EE	0.0002×10^{-16}	0.3299×10^{-15}	0.00006	8
LV	0.0006×10^{-16}	0.0017×10^{-15}	0.03509	2
LT	0.00004×10^{-16}	0.0090×10^{-15}	0.00044	7
PL	0.0014×10^{-16}	0.0082×10^{-15}	0.01671	3
FI	0.0017×10^{-16}	0.0620×10^{-15}	0.00275	6
SE	0.0078×10^{-16}	0.0574×10^{-15}	0.01356	4

Table 11
The rankings of the countries by neutrosophic MULTIMOORA method, 2008.

	The neutrosophic ratio system	The neutrosophic reference point	The neutrosophic full multiplicative form	Final rank
DK	4	1–2	1	1
LV	1	6	2	2
PL	3	5	3	3
SE	6	1–2	4	4
DE	5	3	5	5
FI	7	4	6	6
LT	2	7–8	7	7
EE	8	7–8	7	8

Table 12
The neutrosophic ratio system objective for the examined countries, 2015.

	Q_i	$S(Q_i)$	Rank
DK	(0.8810 0.1163 0.1293)	0.8798	3
DE	(0.7814 0.2252 0.2388)	0.7730	8
EE	(0.8044 0.2046 0.2059)	0.7973	7
LV	(0.9062 0.0943 0.1154)	0.9006	2
LT	(0.9101 0.0886 0.1106)	0.9056	1
PL	(0.8750 0.1255 0.1505)	0.8684	4
FI	(0.8377 0.1647 0.1811)	0.8318	6
SE	(0.8416 0.1618 0.1760)	0.8355	5

Table 13
The neutrosophic reference point objective for the studied countries, 2015.

	$\max\lvert D(r_i - w_i(x_n^*)_{ij})\rvert$	Rank
DK	0.9868	2
DE	0.9914	7
EE	0.9896	4
LV	0.9825	1
LT	0.9938	8
PL	0.9904	5
FI	0.9911	6
SE	0.9886	3

Table 14
The neutrosophic full multiplicative form objective for the countries, 2015.

	$S(A_j)$	$S(B_j)$	U_j	Rank
DK	0.1354×10^{-16}	0.0025×10^{-14}	0.54280	2
DE	0.0011×10^{-16}	0.2665×10^{-14}	0.00004	8
EE	0.0100×10^{-16}	0.0571×10^{-14}	0.00175	4
LV	0.0339×10^{-16}	0.0004×10^{-14}	0.82550	1
LT	0.0043×10^{-16}	0.0004×10^{-14}	0.10767	3
PL	0.0006×10^{-16}	0.0074×10^{-14}	0.00079	6
FI	0.0012×10^{-16}	0.0573×10^{-14}	0.00020	7
SE	0.0021×10^{-16}	0.0223×10^{-14}	0.00093	5

Table 15
The rankings of the countries by neutrosophic MULTIMOORA method, 2015.

	The neutrosophic ratio system	The neutrosophic reference point	The neutrosophic full multiplicative form	Final rank
LV	2	1	1	1
DK	3	2	2	2
LT	1	8	3	3
EE	7	4	4	4
SE	5	3	5	5
PL	4	5	6	6
FI	6	6	7	7
DE	8	7	8	8

Table 16
The rankings of the BSR countries and achievements in the 2008–2015 period.

Country	Final rank 2008	Final rank 2015	Change
DK	1	2	− 1
LV	2	1	+ 1
PL	3	6	− 3
SE	4	5	− 1
DE	5	8	− 3
FI	6	7	− 1
LT	7	3	+ 4
EE	8	4	+ 4

implemented the EU's energy policy objectives, some indicators dropped during the period considered, which led the country to give the first place to Latvia in 2015. Since 2013, Denmark has been a country that imports energy rather than exports it (until then it was the only country in the region in which energy import dependency was negative), as well as energy prices were the highest in the BSR.

The Effort Sharing Decision sets national annual binding targets for GHG emissions not covered under the EU emission trading scheme. The targets of GHG emissions for all MS were determined by considering the country's current situation and its growth potential. The biggest GHG target (-20%) was established for Denmark among all the BSR countries. Having considered the latest national forecasts and the existing measures, the amount of GHG in sectors not covered by the EU Emissions Trading System by 2020 will decrease by 19%. Therefore, Denmark needs to pay more attention to this area and implement additional measures to reduce GHG emissions further. Energy policy of Denmark is exceptionally coherent with the EU objectives: in 2017, the Danish government announced that it will seek to produce 50% of all energy needed from renewable sources by 2030. Also, to achieve long-term objectives of the EU and move towards low-carbon, fossil-fuel free society by 2050, the country will seek to reduce GHG emissions by 80–95%.

At more than 30% in 2015, Denmark has already reached its 2020 target for the share of renewable energy in final energy consumption (30%). The most significant progress is in electricity generation (biomass, wind energy) and heating (biomass), but fossil fuels still dominate in the energy balance. Concerning gross inland energy consumption (2015), oil accounts for 38.6%, renewable energy for 28.4%, natural gas for 17,1%, and coal for 10.3%. 65.5% of gross electricity generation comes from renewable energy sources, and 24.5% from coal. Denmark has consistently reduced both primary and final energy consumption since 2010 and has already achieved both objectives of energy efficiency, which are even lower than those established (17.4 Mtoe of primary and 14.4 Mtoe of final energy consumption). With the further move towards sustainable energy policy, the Danish government has set even more ambitious energy efficiency targets than those established by the EU. Danish energy dependence on imports is one of the smallest in the BSR countries (13.1%) and also throughout the whole EU; however, gas infrastructure projects have been launched in recent years to ensure the security of gas supply (European Commission, 2017c). These projects are the upgrade of capacity at the Ellund interconnection point between Denmark and Germany; the Project of Common Interest (PCI) Poland-Denmark interconnection "Baltic Pipe"; the Tie-in project connecting Denmark and Norway; the PCI project Gothenburg LNG Terminal.

Estonia. Estonia, as well as Lithuania, made the most significant progress during the period concerned mainly due to the policy measures are undertaken to increase energy independence, promote market competition and implement EU energy policy objectives. Estonia has already reached its 2020 targets on the increase the portion of RES in final energy consumption, increase in energy efficiency and consumption. For the GHG reduction target, national projections indicate Estonia will exceed its 2020 target by 13%.

Although Estonia has achieved primary and final energy consumption levels, to maintain these levels by 2020 is still a considerable challenge as fossil fuels in the final energy consumption is the basis of energy and the economy of the country is growing. The challenge is related to GHG emissions: increase in emissions from transport sector has been observed lately. Moreover, transport sector of the country consists of one of the most polluting cars. Therefore, it is important for Estonia to look for the instruments to improve efficiency and implement them as soon as possible (European Commission, 2017d). As far as energy dependence is concerned, Estonia is the most independent of imports not only in the BSR but also throughout the whole EU, accounting for only 7.4%, while the EU average is 54.03%.

Finland. Although Finland is seeking to reach the goals of Europe

2020 strategy, additional measures are needed to ensure that climate objectives are met. Finland takes one of the last positions among the BSR countries: energy consumption per capita is the largest, there is no competition in the gas market, and there are rather high carbon dioxide emissions per capita.

The portion of RES in gross final energy consumption reached 39% in 2015 and exceeded its 2020 target (38%). Primary and final energy consumption in 2015 was already below their 2020 energy savings targets. The promotion of RES and energy efficiency helps to reduce dependency on imported energy. Import dependency 46.8% in 2015. Regarding GHG emissions, according to the national projections, the reduction in emissions in the non-ETS sector by 2020 will be 16%, but there is no guarantee that the target will be met.

In 2016, the Finnish government approved a National Energy and Climate Strategy by 2030. The strategy defines particular measures to reach energy and climate objectives by 2030, which conform to the general EU objectives. Such goals include increasing the portion of RES above 50% in the 2020 s, encouraging the use of advanced biofuels, and promoting transport electrification. The aim is also to promote cost-effective measures to reduce GHG emissions. The electricity market is working well in Finland. There is also a widespread deployment of smart meters. However, there is lack of sufficient electricity interconnector capacity with the Nordic and Baltic countries, especially Sweden.

Currently, there is a lack of competition in the gas market. The market is strictly regulated, there is no liberalised wholesale market, while the end users cannot to choose suppliers. The situation is being solved by the construction of new gas connections (Balticconnector pipeline project) and liquified natural gas (LNG) terminals. A first local LNG terminal was opened in 2016 in the port of Pori (European Commission, 2017e). Also, there are more LNG projects: Tornio Manga LNG receiving terminal will be opened in 2018, LNG in the port of Hamina will be opened in 2020.

Germany. Germany is the only one country from all the BSR countries, which has not reached all its 2020 targets. Germany fell by 3 positions during the period concerned and was the last in ranking in 2015: the country is heavily dependent on energy imports, there is a lack of competition in the energy market, EU energy policy objectives are implemented too slowly, and there are high carbon dioxide emissions per capita.

Regarding gross inland energy consumption (2015), oil accounts for 34.18%, coal for 25.3%, natural gas for 20.75%. More than 60% of the gross inland energy consumption in 2015 came from imported sources. Therefore, Germany energy dependence is one of the biggest in BSR. Security of energy supply is one of the most actual issues in the country, and it is essential to building new interconnections between EU countries. The country failed to reduce its energy consumption practically in all sectors (European Commission, 2017f). Although Germany has reduced its primary and final energy consumption, the analysis of data of the last decade and evaluation of economic growth suggest that the country is unlikely to reduce primary (-16.3 Mtoe) and final (-17.8 Mtoe) energy consumption to the established targets as this represents about 8% and 7% of total energy consumption respectively.

It is highly unlikely whether Germany will achieve its GHG emission reductions target (410,91 Mtoe). Under EU requirements, Germany has to reduce its GHG emissions in sectors that are not covered by the EU emission trading system by 14%. In 2015 country reduced its emissions by about 10%.

Latvia. Leading together with Denmark in the area of implementation of sustainable energy policy goals, Latvia was the most sustainable country in this aspect in the BSR in 2015: energy consumption per capita is the lowest, EU policy objectives have been exceeded (except for RES, but they are one of the biggest in the EU), carbon dioxide emissions are the lowest per capita. Although Latvia has a significant share of RES in its energy balance and is only after Sweden and Finland among the BSR countries, it remains dependent on imports of fossil fuels (51.15%), i.e. on imported gas from Russia in particular. The opening of Klaipėda LNG terminal in Lithuania gave an alternative from 2015. It is also expected to reduce its dependence after merging with the European market (Gas Interconnection Poland-Lithuania (GIPL) project).

Latvia has the largest concentration of electricity market in the BSR countries and takes the third place (after Cyprus and Malta) in the whole EU. Moreover, although the connection of electricity networks between Latvia and the neighbouring countries is being tried to increase, weak points are the Estonian and Latvian transmission line and the Latvian internal electricity networks. Therefore, security of supply and the development of a competitive energy market depend on the development of internal infrastructure and the development of infrastructure for electricity and gas links. The principal objective of the Baltic Energy Market Interconnection Plan (BEMIP) is to connect isolated Baltic countries with the single EU market. Currently, the modernisation of the Inčukalns underground gas storage site, the strengthening of electricity and gas transmission systems and the synchronisation of the Baltic electricity networks with the European networks are among the main priorities in Latvia (European Commission, 2017g). Since 2018, the Latvian gas market has been opened to make use of the advantages of the opened market, such as the creation of competition, price decrees. However, the active market can only be expected after the realisation of infrastructure projects. Energy market integration in Latvia continues with improving network connections and the market opening of the gas markets in the broader BSR. Unbundling and full opening of the gas market for the competition is a priority area of energy policy in Latvia.

The target of Latvia in implementing Europe 2020 strategy is to produce 40% of energy from RES. According to the data of 2015, RES account already for 38%; it is therefore very likely that this target will be achieved. As far as the increase of energy efficiency is concerned, both primary energy (5.4 Mtoe) and final energy (4.5 Mtoe) conception targets did not exceed in 2015, i.e. energy consumption is less than the established maximum. Most probably, alongside the growth of competition and investments in infrastructure, these goals will be realised even with the growth of the national economy. For Latvia, if compared with the target in 1990, a + 17% GHG (9.99 Mtoe) has been established. According to the data of 2015, GHG in Latvia stands at 9.01 Mtoe.

Lithuania. Lithuania as well as Estonia rose by 4 positions during the period concerned and took the third place in ranking among the BSR countries in 2015 concerning the implementation of the goals of sustainable energy policy. Lithuania is distinguished by low energy prices and low energy consumption (energy per capita), but also for low energy independence during the period concerned. However, recently completed energy infrastructure projects in Lithuania and cooperation with neighbouring countries have increased the security of energy (gas and electricity) supply. Regarding the liquefied natural gas (LNG) terminal and the construction of the pipeline in Lithuania, Baltic countries now have access to the independent source of gas. Lithuania also works on the gas interconnection Poland–Lithuania (GIPL) which seeks to integrate the gas markets of the Lithuania, Latvia, Estonia and Finland into an EU gas market. It is provided to complete the GIPL by 2021.

Electricity interconnection with Finland via Estlink1 and Estlink2, with Poland through LitPol Link and Sweden via NordBalt, have significantly increased the capacity of electricity networks in recent years: it was only 4% in 2014, while in 2017 it already stood at 22% and twice exceeded the target of 10%. Nevertheless, Lithuanian energy is heavily dependent on imports (78.44%), and the primary energy suppliers are non-EU countries. Both gas and electricity infrastructure projects had a positive impact on the wholesale and retail prices of electricity and gas in Lithuania and other Baltic countries. Today, one of the primary goals of each Baltic country concerning the electricity market is to synchronise electricity networks with the European network, which for the historical reasons operate in a synchronous mode with Belarus and make the so-called BRELL ring (European Commission, 2017h). The works are carried out consistently following the BEMIP plan, and the target is planned to be achieved by 2025.

In 2015, Lithuania exceeded the targets of RES outlined in the strategy Europe 2020 and accounted for 25.8%. The heating sector with 46.1% of RES made the most significant input in the achievement of this target, 44% of which was obtained from biomass and waste incineration. Electricity generation accounted for 15.5%. Primary energy consumption is less (4.3 Mtoe) than that established, so the target has been achieved so far; however, the target of final energy consumption has not yet been achieved yet. 0.6 Mtoe more is consumed than intended. For Lithuania, if compared with the target of 1990, a + 15% GHG target (15.46 Mtoe) has been established. According to the data of 2015, GHG stood at 13.25 Mtoe in Lithuania.

Poland. Poland is one of the most energy-intensive economies in the EU. Economic growth has allowed Poland to stay among several MS, which have not reduced their energy consumption practically in all sectors since 2005. Polish energy industry is based on fossil fuels (about 80%) and is very inefficient and hardly meets with increasing energy demand: more than 60% of power infrastructure is older than 30 years and requires huge investments for modernisation, capacity enhancement and increased production and supply efficiency. Although the possession of local energy resources ensures the security of energy supply, this turns into a challenge for the implementation of both economic and sustainability goals.

Although emissions and efficiency targets set out by the latest statistics have not exceeded, the economy of Poland is growing, which results in increased energy consumption and higher GHG emissions. The implementation of these objectives will depend on the consistency and administration of national policy as well as on funding and the choice of legal instruments. For Poland, if compared with the target of 1990, a + 14% GHG target (205.18 Mtoe) has been established. According to the data of 2015, GHG stood at 186.77 Mtoe in Poland. Although there are individual attempts to modernise the objects of infrastructure, there is still no long-term and consistent vision of national energy policy of Poland (European Commission, 2017i). The development of energy infrastructure and new links remain an essential task in developing energy security and efficiency in Poland.

Upon implementation of the plans of LNG terminal, Poland has significantly improved the security of gas supply. A national gas transmission and distribution network has also been created, yet the network development is delayed in due time, which makes it remain ineffective. The level of interconnection in the electricity sector in 2016 was only 4%, i.e. at lowest in the EU. LitPolink electricity link with Lithuania began in 2016 and improved the situation; however, reaching a target of 10% by 2020 will be rather complicated. Although the share of RES for Poland is the lowest among all the BSR countries (15%), the country failed to reach the goal in 2015: the implementation level stood at 80%. Although RES development is included in the national plans, there are still delays in the implementation of plans as well as a lot of administrative, legal and financing difficulties.

Sweden. The Swedish energy system is distinguished for a shallow use of natural gas, oil and coal and a considerable portion of RES in all sectors, except for transport, which still primarily dependent on oil. Regarding gross inland energy consumption (2015), renewable energy accounts for 42.2%, nuclear for 32%, oil for 22.5%. 65.5% of gross electricity generation comes from renewable energy sources, and 24.5% from coal. The portion of RES is one of the biggest in the EU and oversteps the 2020 target. Sweden has set ambitious national targets for energy efficiency. Energy consumption is decreasing last few years, but the country is not reached the energy efficiency targets yet. Nuclear and renewables energy accounted for 99% of gross electricity generation in 2015.

The transmission system of electricity is well interconnected with Norway, Finland and Denmark. Also, the NordBalt project has improved the interconnection capacity for electricity of 25% between Sweden and Lithuania in 2017. The electricity sector in Sweden has been successfully liberalised and is characterised by high competition in the retail market and low concentration among electricity producers. Since gas makes only about 2% of energy consumption, gas security is not a big problem even though gas was supplied from a single supplier, i.e. Denmark, until 2016. Gothenburg LNG Terminal provides a second access point for gas supply in the country from 2016 (European Commission, 2017j). As far as gas prices are concerned, they are high enough: higher than the average in the EU and the OECD. A target to reduce GHG emissions by 17% has been established for Sweden, and the country has already achieved this target and exceeded by 2.18 Mtoe in 2015.

4. Conclusions and policy implications

Sustainable energy development is a crucial principle in the European energy policy, in solving the most urgent energy issues and challenges facing each EU country: reduce dependence on import of energy, increase security in the energy supply and to achieve goals for reducing GHG emissions and protect the environment. The BSR is an important region in the EU, which involves eight EU countries, which develop internal energy policy based on different energy projects. However, there is a lack of studies on how BSR countries achieve ES energy policy goals and which factors and how influence sustainability of member states in the region.

The policies and measures aiming at promotion of sustainable energy development implemented in Baltic Sea Region countries have many similarities as the same mechanisms foreseen in EU directives are applied for promotion of energy efficiency and renewables.

The paper presents an original framework for sustainable energy development indicators, which could be useful to assess energy policy sustainability or implementation level of energy policy goals of other EU regions or individual member states.

The most critical sustainable energy development indicators were selected based on the EU energy policy priorities for the comparison of the BSR` countries regarding the success of implementing sustainable energy development goals.

To reflect countries' different situation and ability to achieve the sustainable energy goals, environmental, economic and social indicators were selected from sustainable energy development indicators list. Environmental indicator essential targets of EU energy policy (reduce GHG emissions, increase the share of RES in final energy consumption, increase in energy efficiency). Also, there are involved 5 economic indicators for monitoring progress of energy security in the EU, which is an issue of sustainable energy development in the region and a part of energy policy in the EU. 5 social indicators were selected to reflect on critical social issues in the EU energy sector.

The comparative assessment of BSR countries, based on MULTIMOORA technique, by integrating relevant economic, social and environmental indicators indicated that the best-performing countries regarding the achievement of EU sustainable energy development goals during the research period were Denmark and Latvia: in 2008, Denmark was ranked first, leaving Latvia in the second place. These two countries exchanged positions in 2015, because of energy import dependency rate of Denmark started to be positive, until then Denmark was the only country in the region in which energy import dependency was negative, i.e. Denmark was exporting country.

The assessment shows that Estonia, as well as Lithuania, made the most significant progress during the period concerned mainly due to the policy measures are undertaken to increase energy independence, promote market competition and implement EU energy policy objectives. Lithuania is distinguished by low energy prices and low energy consumption, but also for high energy dependency during the period concerned. After the final closure of Ignalina NPP in 2008 Lithuania became net energy importer.

The comparative assessment indicated, that Finland takes one of the last positions among the BSR countries: energy consumption per capita is the largest, there is no competition in the gas market, and there are rather high carbon dioxide emissions per capita.

Analysis of indicators shows that Germany is the only one country from all the BSR countries, which has not reached all its 2020 targets and fell by 3 positions during the research period and was the last in ranking in 2015. Germany is heavily dependent on energy imports, there is a lack of competition in the energy market, EU energy policy objectives are implemented too slowly, and there are high carbon dioxide emissions per capita.

Poland dropped in rank from the third to the sixth during the investigated period, and it is one of the most energy-intensive economies in the EU, which have not reduced its energy consumption practically in all sectors since 2008.

The Swedish energy system is distinguished for very shallow use of natural gas, oil and coal and a significant portion of RES in all sectors and low carbon dioxide emissions per capita. This country has maintained the same position in ranking based on the implementation of sustainable energy development goals in 2008 and 2015.

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