POLITICAL, ECONOMIC, SOCIAL AND TECHNOLOGICAL PERSPECTIVES OF AGGREGATOR OF DEMAND RESPONSE FOR RENEWABLE INTEGRATION

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Abstract

With the development of renewable energy, many consumers have also become producers, installing, for example, solar panels or small wind generators to cover their own consumption, also, have access to local renewable-based generation and advanced forms of technology and information. RES have a direct link to the weather, resulting in situations when the produced electricity exceeds the subject's consumption and vice versa, the electricity is in deficit. Therefore, there is obvious need for transition from traditional approach of power distribution and balancing, where end-consumers of electricity have typically been passive in their participation in electricity markets to new approach that promotes their active participation. To this aim, the paper presents an analysis of regulatory and economic frameworks of aggregator of demand response for renewable integration, research on an impact of wind power on wholesale prices of electricity for Latvia's division of Nord Pool platform.

Keywords

renewable energy; energy market; demand response; aggregator

JEL classifications

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1 INTRODUCTION

The energy industry all around the world is currently undergoing changes due to the development of new technologies, user requirements and restrictions on the availability of natural resources, which are stimulating companies to expand and revise their business, offer new services and open up new markets. Increasing global demand for energy, limited supplies of fossil fuels, as well as environmental pollution and the threat of global climate change have led to increased interest in renewable energy sources. [2] The use of renewable energy sources is considered a key element of energy policy, reducing dependence on fuel imported from third countries, reducing emissions from fossil fuels and decoupling energy costs from oil prices. [1]

In the modern world, everything is connected - as one industry changes, so do others and the chain continues to infinity. The energy field also does not stand still. Not only technology but also business models in the energy sector are developing.

More effective use of Europe's energy potential requires the involvement of all energy market players. The core of any business model is a consumer. A consumer is the point of reference that defines the vector of business development. Today, the energy industry is undergoing a transformation where the consumer is no longer just a point; it turns into a vector itself. Decentralization of the power system through the involvement of active consumers, citizens and local authorities in the operation of the system is currently widely used in Europe. Active consumers are defined as electricity consumers that use, store or sell their own electricity or participate in demand change and energy efficiency schemes. [1]

The Latvian electricity market has been liberalized since 2015, and households as well as legal users can freely choose their trader by agreeing on the electricity price. Since 2013, electricity trading has also been carried out within the Nord Pool exchange. Currently, 38 companies operate on the Latvian electricity market. The Latvian electricity market, like the entire Baltic energy market, is currently linked to the common European energy market by two cables connecting the power systems of Estonia and Finland: Estlink I with a transmission capacity of 350 MW and Estlink II with a transmission capacity of 650 MW. Lithuania-Poland is connected by a LitPol Link 1 interconnection with a transmission capacity of 500 MW. It is also complemented by the Lithuanian-Swedish interconnection NordBalt with a transmission capacity of 700 MW.[13]

Demand management can significantly affect electricity prices, reduce the need for the construction of generating and network capacities, promote the integration of renewable energy and electric transport, maximize the effect of the introduction on the consumer side of such innovative digital technologies as the Internet of Things, Smart Home. However, in order to obtain such benefits, Demand Management (DM) for electricity must become sufficiently widespread through the participation of a sufficient number of industrial, commercial, agricultural and residential consumers.

The demand management mechanism (Demand Response - DR) implies a voluntary reduction in electricity consumption by the end user, in particular, during periods of peak prices in the wholesale market, with an economic benefit for such a decrease.[1] However, demand management resources, and significant ones, are also available in the retail market. In world practice, the main solution for involving consumers in the retail market in demand management has become the creation of specialized organizations - demand management aggregators.

According to the Decree of the Cabinet of Ministers developed on 02/04/2020, in order to increase the stability and security of the energy system, it is necessary to develop a legal basis for the operation of aggregators until 2022, to define the rights and obligations of the aggregator, payments for its services and relations between the aggregator and other participants in the system and the market. This will increase the balancing capacity and flexibility of the system.

Methodology: This research based on a literature review and statistical databases, comparative analysis, qualitative and quantitative research. Research period: from 2016 to 2019.

2 REGULATORY AND ECONOMIC FRAMEWORKS

High final electricity prices impose a significant cost burden on households and generating companies, thus also affecting the country's competitiveness. Electricity prices are determined by various factors, such as fuel structure, cross-border interconnections, markets interconnection, renewable energy, concentration of market suppliers, weather conditions, etc.[4]

On 30 November 2016, the European Commission issued a report entitled ‘Energy prices and costs in Europe’, which stated that, although wholesale energy prices in the European Union reached their lowest levels in 12 years in 2016, household prices have risen by an average of 2-3% per year, but electricity prices for industrial consumers increased by about 2%.[7] Concluded that Member States need to better assess the need for such mechanisms, while ensuring security of energy supply while minimizing competition distortions and keeping electricity prices paid by consumers low. [10]

2.1 General Sector Overview

The use of energy is the key to humanity. It helps to develop and adapt to the changing environment. Today's society consumes enormous amounts of energy, so the energy sector is very important worldwide. Energy supports all aspects of modern life, contributing to economic growth and prosperity, thus has a direct link to people's living standards.

Based on the statistical classification of economic activities in the European Community, NACE Rev. 2, the industry is classified as:

- D section "Electricity, gas, steam and air conditioning supply"
- 35. "Electricity, gas, steam and air conditioning supply"
- 35. 1 "Electric power generation, transmission and distribution"
- 35. 1.1 "Production of electricity". This class includes: - the production of electricity from cogeneration units, nuclear power plants, hydroelectric power stations, gas turbines or diesel generators and from renewable energy sources. [9]

According to the Central Statistical Bureau last data, there were 347 economically active commercial companies (market sector) in Latvia at NACE D 35.11 in 2017.[3] Latvian enterprise database Lursoft, shows that in March 2019, 489 companies with this NACE code registered in Latvia.

2.1.1 Regulatory framework

In November 2018, The European Commission published a strategic long-term vision for a prosperous, modern, competitive and neutral economy for 2050. The strategy reflects on how Europe can move forward towards climate neutrality by developing new technological solutions and coordinating important areas such as industry, finance and research. It will be based on the new energy policy system created in accordance with the „Clean Energy for All Europeans" package which gives the European consumers rights to become active participants in the energy transition stage and sets two new goals for the EU for 2030: at least a 32% renewable energy target and at least a 32,5% energy efficiency target - with a possible upwards re-calculation. For the electricity market, it sets a 15% interconnection target by 2030. Miguel Arias Cañete, the EU Commissioner for Climate Action and Energy, states that the EU is on the right track to achieve the RES target, indicating that Europe is the world's first major economy that is planning on becoming climate-neutral by 2050 and reaching an 80% RES target. These statements will promote the competitiveness, overall growth and employment of the European industry, decrease electricity costs, help prevent energy loss and improve quality. [10]

EU 2030 Energy Strategy targets:

- decrease the greenhouse effect gas emission level by 40% in comparison to 1990;
- at least 27% of renewable energy consumption;
- improve energy efficiency at the EU level by at least 27% (in comparison to the prognosis) which must be reviewed until 2020 (namely, the EU level is 30%);
- support the improvement of the internal energy market by reaching the electricity interconnection target - 10% by 2020, in order to reach 15% by 2030. [8]

In the Republic of Latvia, the Parliament has issued a development planning document of the highest importance – "Sustainable Development Strategy of Latvia until 2030" – that defines the renewable and safe energy target for the development of the country's energy independence by increasing the energy resource self-sufficiency and integrating in the EU energy network. The strategy is comprised of certain energy development measures, projects and national targets for determining the energy and energy resource self-sufficiency. The main criteria for achieving energy sufficiency and availability is a balanced, effective, economically, socially and ecologically-based further development of the industry. To meet the set objectives, an industry-specific target and action document that covers the essential dimensions of the energy industry - "2030 Energy Strategy" - was created. In order to determine the national priorities for 2030, 7 tightly interrelated directions are put forward:

- decrease electricity and natural gas import from existing third world country suppliers by 50%;
- achieve the reduction of building heating consumption to 100 kWh/m2;

- achieve a 50% renewable energy resource proportion in the final energy consumption as well as increase the renewable energy consumption in transportation;
- guarantee alternative solutions for the supply of natural gas and legal circumstances for opening the natural gas market in Latvia in 2015;
- create electricity and natural gas markets;
- increase the cross-border electricity interconnection capacities in order to reduce the price differences in different energy exchange auction areas;
- offer support for creating an attractive environment for investments and developing the national economy by promoting the transition to energy efficient technologies and reducing energy costs for its users. [9]

Some of these objectives have already been obtained some of them partially, but only a common and effective implementation of these performance indicators can guarantee a sustainable development of the energy industry.

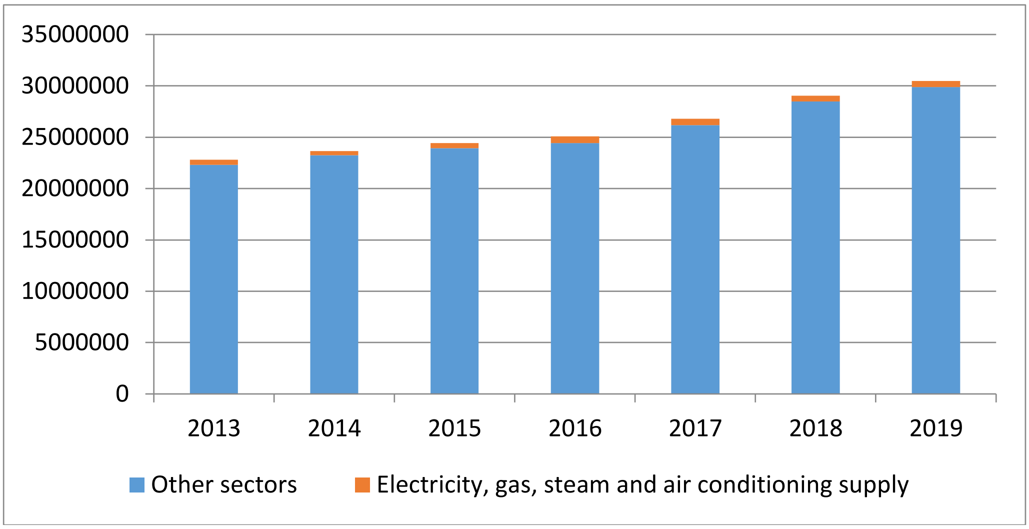
Renewable energy resources will mostly dominate when forecasting Europe’s offer. It is expected that by 2050 wind energy will amount to approximately 30% of the total production capacity. Regarding fossil power, it is planned to build mostly natural gas power plants in Europe. By 2050, nuclear energy and coal power station capacity will decrease to 10% of the total installed capacity. Overall, the fossil production capacity will be reduced from 50% to 30%. [8]

2.1.2 Economic framework

Authors began with the industry contribution to one of the most important indicators of the country's economic development - gross domestic product. Although GDP is commonly used at constant prices, which takes into account inflation, to compare the volume of goods and services, the author examined the contribution of industry to GDP in real (average) prices, which includes changes in output and price.

There are three main sources of electricity generation in Latvia - hydroelectric power stations, large cogeneration units and other cogeneration units. To a much lesser extent, electricity is generated from small hydro, wind and biogas plants. This fact confirms the promising growth and development of this industry sector.

Figure 1: Electricity, Gas, Steam and Air Conditioning Supply Share in Latvia's GDP 2013-2017 years, real prices, '000 EUR

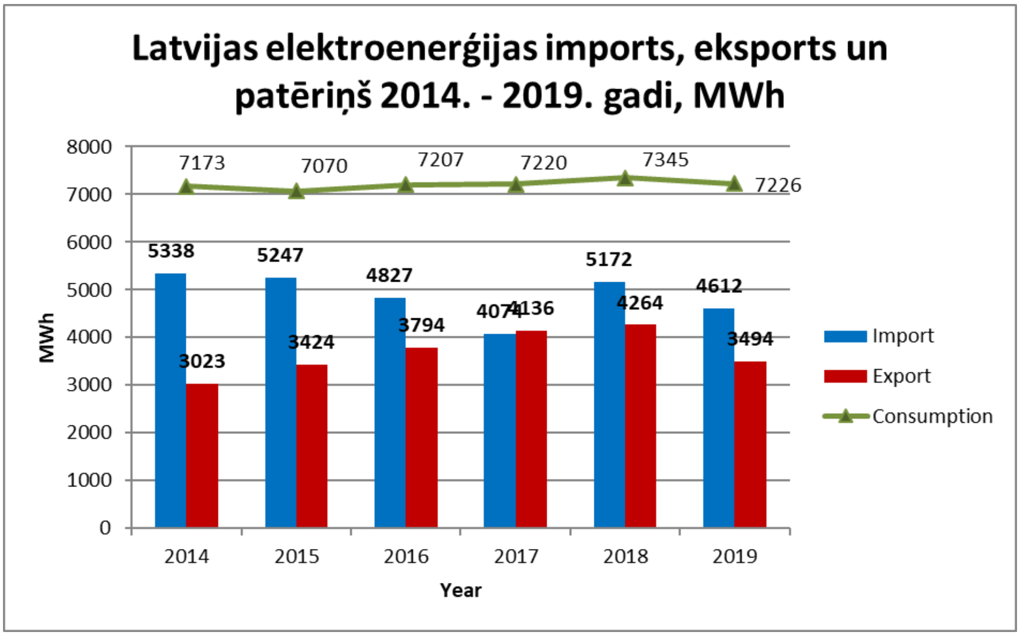


Source: Created by the authors, using [3] dates

The figure shows the share of electricity, gas, heating and air conditioning in the GDP of Latvia in the period 2013-2017. The graph is in absolute terms, but the authors have given a percentage to make it easier to understand the sector's share of GDP. Summarizing the results, it can be stated that the average contribution of the industry to the national GDP is 2.23% during the five years given. The largest increase was in 2016, from 2.09% share in 2015 to 2.55% in 2016. Industry made the smallest contribution to GDP in 2014, calculated 1.78% in total volume that year. The sector's contribution to Latvia's GDP has been stable over the years, with positive growth prospects. (See Figure 1) [17]

The production and consumption of energy resources is a major factor in the global economy. The energy sector is stimulated by global energy supply and demand. Latvia belongs to those countries that are heavily dependent on imported energy resources because they are unable to fully meet the required electricity consumption. The volumes of electricity import, export and consumption in Latvia for the period 2014-2019 were defined.

Figure 2: Latvia's Electricity Import, Export and Consumption 2014-2019 years, MWh



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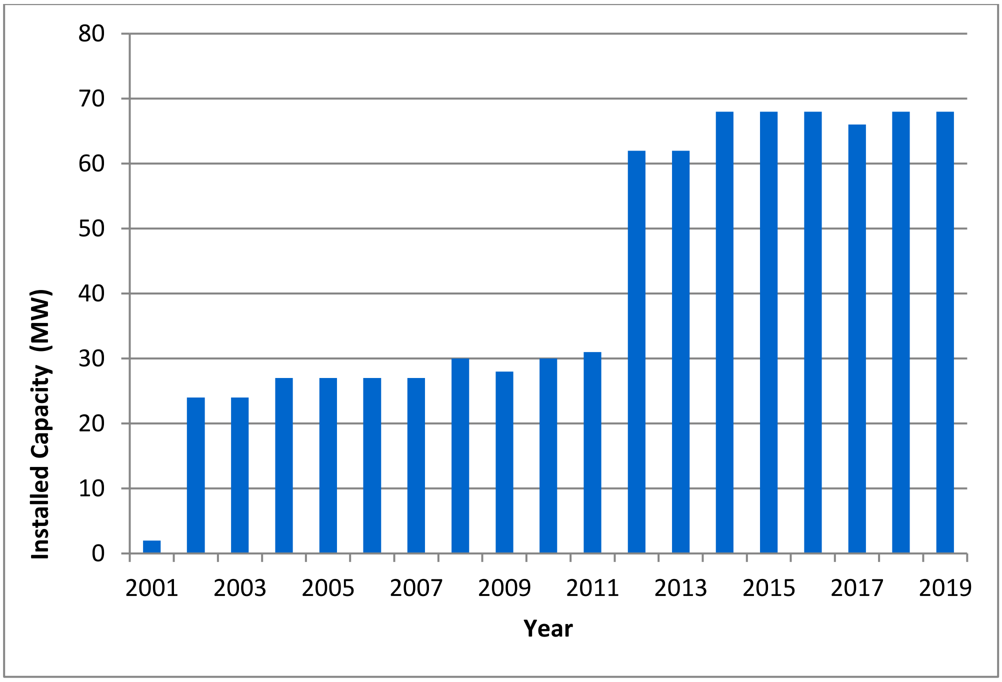
According to the Latvia's Central Statistical Bureau, there have been no significant fluctuations in final energy consumption over the last decade. The major consumers of energy resources are the transport sector, agriculture, forestry, households. According to Figure 2 the consumption has a minimal tendency to grow. Over the last 25 years, there has been a gradual development of production, transmission and distribution through new projects, renovations and repairs. Along with the increase in production, the export of electricity has also increased. During the five years shown on the graph, there is no uniform trend in electricity import, it is fluctuating. In 2017 Latvia's export exceeded import. Latvian domestic generation covered 101% of electricity consumption. Compared to 2016, export increased by 9% in 2017, import fell by 15.6% and consumption grew by 1.7%. JSC *"Augstsprieguma tīkls" (AST)* mention in electricity market report that hydroelectric power plants (HPP) production increased by 74% in 2017, thermal power plants (TPP) production decreased by 34%, wind farms connected to transmission production increased by 0.03% and the electricity volumes generated by renewable and supported electricity producers (biomass, biogas, wind power plants, hydroelectric power stations, solar power plants) with installed capacity up to 10 MW increased by 6%. [12] The amount of electricity generated by hydroelectric power plants influenced the reduction of fossil fuel power station generation volumes and was a major contributor to the positive energy balance. In 2018, Latvia's total electricity production was 7 346 336 MWh; compared to 2016 the increase was equal 18%. (See Figure 2)

Turning to the Latvia’s development trends of renewable energy sources, the authors wishes to mention the topical issues of RES defined by Latvian Wind Energy Association, which mentions two factors: “Latvia's great dependence on energy resources from Russia and the desire of the country to increase self-sufficiency and independence in this area; There is a tendency in the world, and especially in Europe, to increase the use of green or renewable energy in our daily lives.” [17]

The use of wind resources is the second largest form of electricity generation in Europe. On average, wind farms in the EU operate at 35% onshore and 50% offshore, with total installed wind turbines of approximately 178.8 GWh in 2018.

Figure 3. Total Installed Capacity of Latvia’s Wind Turbines in 2001 - 2019, MWh

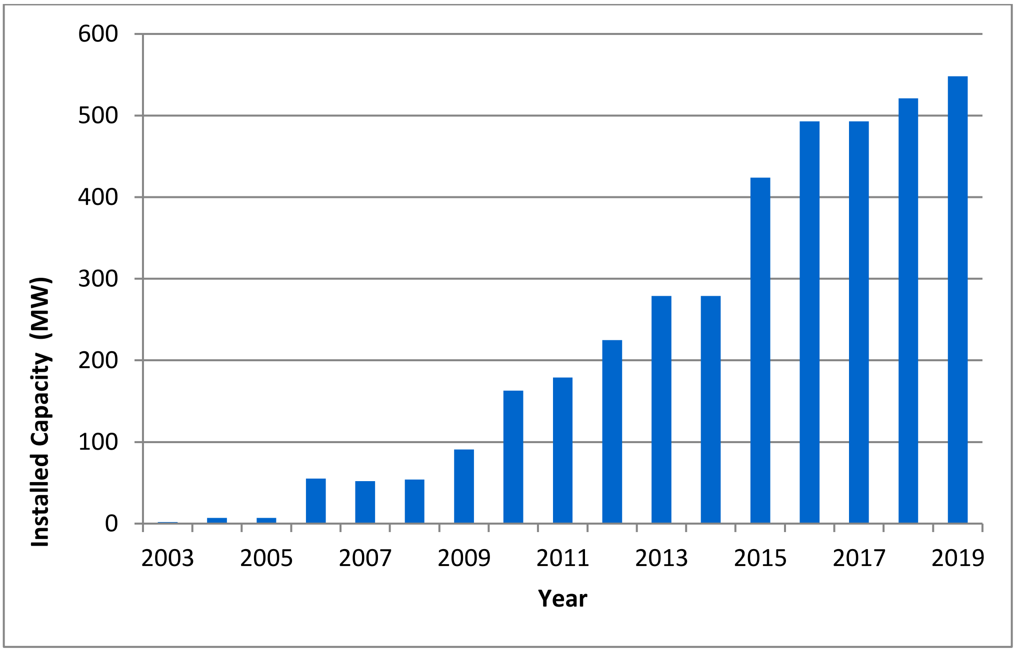


Source: Created by the authors, using [14] dates

The first wind generators in Latvia were installed in 1995, but their total installed capacity was insignificant. The total installed capacity in 2001 was only 2 MWh, but next year it increased significantly (to 24 MWh). The next leap was observed in 2012, when installed capacity increased rapidly to 62 MWh. This rapid increase can be explained by the start of exploitation period of several plants, including the producer Ltd. "Winergy", with installed capacity of 20.07 MW. (See Figure 3)

The total installed capacity of wind turbines in Latvia is now about 66 MWh, which allows to produce about 1.8% of the electricity consumed. In contrast, in Estonia, the installed capacity is more than 300 MWh (about 8.5% of electricity consumed) and in Lithuania more than 500 MWh (10.5% of electricity consumed). (See Figure 4)

Figure 4. Total Installed Capacity of Lithuania's Wind Turbines in 2001 - 2019, MWh



Source: Created by the authors, using [14] dates

Denmark was the leader in wind power generation in the European Union in 2018, where wind power contributes significantly to the electricity balance, it makes 41% of total electricity consumption in Denmark.[18] In the second place was Ireland with 28%, followed by Portugal with 24%. In 2019, wind energy made 14% of total electricity demand in the European Union and increased for 2% compared to 2018. [7]

2.2 Perspectives of Aggregator of Demand Response for Renewable Integration

2.2.1 Factors influencing electricity exchange price in Latvia

Electricity wholesale in Latvia takes place on the Nord Pool [15] electricity exchange, where the Latvian trading area was opened on 3 June 2013 for the next day's electricity market (Elspot) and on 10 December 2013 for the current day's market (Elbas) [14]. As practically all electricity trade transactions in the Latvian area are performed in the next day market, only the Elspot market is considered in the following analysis.

Comparing the correlations with the wholesale price of electricity in the Nord Pool Latvian trade area with various potentially influencing factors, it can be seen that the largest positive correlation is with the volume of consumption and development in Latvia and Lithuania, as well as with electricity generation from certain types of sources: mainly natural gas and oil shale thermal power plants in the Baltic States, Kroņi HPP and HPP. [16] In other words, as the total volume of consumption and generation increases, the price in the market increases. In turn, as the market price increases, certain types of power plants are started up. The price in Latvia has a high positive correlation with the price in the Lithuanian region.[5] This follows from the analysis of Nord Pool data from 2016 to 2020.

However, there are the increased amount (See Table 1) of renewable-based distributed energy resources (DERs) emerging on the demand side of grid. More often are mentioned renewable technology such as solar photovoltaic systems, wind generations, and electric vehicles, but also encompass other resource capacities such as demand response (DR) programs, batteries, micro grids, and small generators. [1]. It is considered challenge by itself to integrate these new technology resources into existing infrastructure and energy markets, adding issues with intermittent nature of renewables DERs, which have the potential to jeopardize system stability.

Table 1: Total Installed Capacity of DER in Nord Pool area and interconnected zones 2020, MWh

2020	Wind Onshore, MW	Wind Offshore, MW	Solar, MW
LV	59		
EE	329		123
LT	534		7
FI	2146		
SE	9648		
NO	3068		
DE	53405	7709	46471
DK1	3645	1277	672
DK2	757	432	341
FR	16578	14	9438
BE	2248	1859	3887
NL	3973	1709	5710
LU	154		170
PL	5956		1310
UK	995		92
AT	3133		1333

Source: Created by the authors, using [15] dates

Not withholding aforementioned, current situation required an understanding of the mechanisms by which aggregators create value, for there are implications for questions such as: what possible impact of regional wind generation on the day ahead electricity prices in Latvia zone? What could be best business model for an aggregator? What are the main barriers for prosumers to be aggregated – technical, economic, social and behavioural?

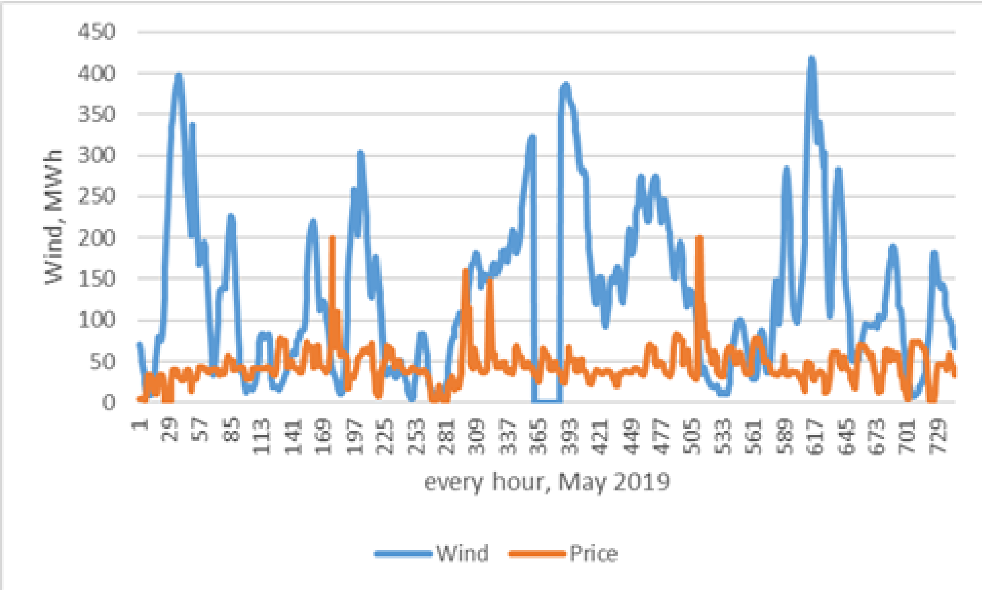
In order to assess in more detail the conditions under which a particularly high next day market price is formed in the Latvian trading area, hourly prices from 2016 to 2019 have been analysed. Hours with atypically high prices have been distinguished. For example, in 2019, in general, especially high prices were relatively rare and 92.4% of hours did not exceed 50 € / MWh. The most frequently observed (~ 29.3% of hours) price was ~ 25–33 € / MWh, followed by prices in the range of ~ 33–41 € (25.8%) and ~ 41–50 € / MWh (19.9%).

However, the price over 50 € / MWh was only 671 hours or 7.6% of the year, including higher than 100 € / MWh only 105 hours or 1.2%, over 150 € / MWh - 39 hours or 0.4%.

The highest prices - over 200 € / MWh - were only 19 hours or 0.2% of the whole year.

As have been mentioned before, the correlation with the wholesale price of electricity in the Nord Pool Latvian trade area with of generated wind energy is considered weak – 0,29. However, for hours with the highest prices situation considerably changes.

Figure 5



Source: Created by the authors, using [15] dates

As can be seen from Figure 5, the highest prices above 200 € / MWh are observed in hours with low wind generation.

3 RESULTS

This paper provides an assessment on DR aggregators from different perspectives, including the regulatory and economic. This study shows that the DR aggregator has the potential to play a key role in creating value that benefits the entire power networks and customers. The position of DR aggregators in the power market is discussed in this paper including what benefits these aggregators actually provide. In order to assess in more detail the conditions under which a particularly high next day market price is formed in the Latvian trading area, hourly prices from 2016 to 2020 have been analysed. Hours with atypically high prices have been distinguished. In addition, the concept surrounding who receives these benefits, what potential issues may be caused by this concept are investigated. In addition, this paper shows that for each case, a feasibility study should be conducted to answer whether the DR aggregator in fact creates a more efficient power system or they are simply transferring rent and adding another step in the process.

4 DISCUSSION AND CONCLUSION

As it was already mentioned, the energy system decentralization is on its active stage, what positively effects renewable energy developing, becoming more accessible even for individuals and motivating even more consumers become active. There is a sufficient potential and wind resource to develop wind energy production and renewable energy in general and increase the total installed capacity of renewable energy generators. There is also room for information and experience – wind energy and other RES are very topical and well developed in the European Union to serve as a model.

Demand management can significantly affect electricity prices, reduce the need for the construction of generating and network capacities, promote the integration of renewable energy and electric transport, maximize the effect of the introduction on the consumer side of such innovative digital technologies as the Internet of Things, Smart Home. However, in order to obtain such benefits, Demand Management (DM) for electricity must become sufficiently widespread through the participation of a sufficient number of industrial, commercial, agricultural and residential consumers.

Future works include development of an aggregator business model for smart grid to arrange the contribution of consumers in a peer-to-peer market, and to quantify the contribution of participants from different perspectives such as contribution to electricity price reduction, reliability, or grid investment. Moreover, a value chain analysis would be useful in future work to determine the value that each aggregator is able to add to the overall energy system.

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