

# EMPLOYMENT AND CHANGING LABOUR MARKET: NEW OPPORTUNITIES IN THE LITHUANIAN LABOUR MARKET

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**Abstract.** In the conditions of modern global economy, the labour market indicators are highly sensitive to economic changes. Labour market dynamics significantly depends from the changes of economic cycle. Under the development of globalization conditions one of the priority objective of the European Union is to maintain and create new jobs according to the migration process. According to the basic indicators characterising situation of employment, the situation and employment trends are evaluated in this article. In this article the following methods of analysis are used: a systematic analysis of the scientific literature, general and logical analysis, comparative analysis, the analysis of statistical data. The new labour market opportunities in the context of a new labour market legislation is highlighted in the article. The carried out evaluation of employment situation allows as to state that despite of improving general employment statistics specific demographic groups still face difficulties integrating into labour market. However, it should be noted, that Lithuania has recently started reforming the labour market by implementing the recommendations of the European Commission. It is believed, that flexibility conferred by new legislation will improve the employment opportunities and Lithuanian labour market will maintain its competitiveness during the economic changes in the context of globalization.

**Keywords:** labour market, employment, globalization, integration, flexibility

**JEL Classification:** J21; J41; J71

## 1. Introduction

Questions of globalization are actively discussed in academic circles and society as well the concept globalisation is widely used in various fields of life and science. This term is used to describe various related and different economic, social, political and business phenomenon. Many authors independently of the paradigm or school they represent, agree that globalization is an important process, changing the structure of world politics, economics and society.

To be emphasized, that in the context of globalization social-economic problems attract different evaluations from world economists (Buch et al., 2014; Martins & Yang, 2015; Cabral et al., 2016). Such situation derives from different perspectives applied to outcomes of the process of globalization. Some scientists see serious dangers in the world economic system, when others assume, that process of globalization is a way leading toward further economic growth and progress. Labour market process obviously relate to globalization, they represent level of productivity in the country and internal trade relations (Cuyvers, 2011; Seo et al., 2015; Aubry et al., 2016). It is important to underline, that globalization of economy had impact on the scope and scale of global migration (Martin & Yang, 2015; Kurekova et al., 2016;

Fernandez, 2016). During the last 30 years due to rapid globalization, rates of migration increased more than ever before – in 2015 number of international migrants reached 244 bln. Around 3 % of the world population comprise people who live outside their native country (International Organizations ... 2012).

In the article, we analyse outcomes of globalization and present analysis of the employment situation in Lithuania in the context of globalization, we discuss impact of globalization to labour market and present what new opportunities and challenges rise for Lithuanian labour market. Research methods: an analysis and summarize of the scientific literature, comparative analysis, analysis of statistic data.

## **2. The consequences of globalization process**

In scientific disputes about the impact of globalization and outcomes stand out approach to positive and negative impact of globalization (Davidson & Sly, 2014; Cabral et al., 2016; Aubry, 2016; Bojnec & Ferto, 2017), as well evaluation of the impact to EU member states.

Global trade openness has boosted EU economic growth, raising prosperity and helping to keep us competitive (IMF, World Bank, WTO, 2017; European Commission, 2017). The EU's share of global goods exports remains above 15 %, having only fractionally declined since the turn of the century and the emergence of China as a WTO member and export powerhouse. Some of our Member States that are most integrated in global supply chains also have both higher incomes and lower inequality. This success has provided resources to support our social model and protect the environment.

Globalisation has had similar positive effects around the world. It has helped lift hundreds of millions of people out of poverty and has enabled poorer countries to catch up. It has played a role in increasing stability, democracy and peace (OECD, 2017).

At the same time, globalisation also poses challenges. Its benefits are spread unequally among people and regions, some of which are less adaptable to change and competition than others. In recent decades, many countries — sometimes with lower wages, environmental standards or taxes — have increasingly competed with Europe in low-skill and low-value added industry segments. The fact that other countries do not all share the same living, social, environmental, tax and other standards as Europe means that companies can use these differences to their competitive advantage. This has led to factory closures, job losses or downward pressure on workers' pay and conditions. Companies that are unable to compete with more productive or cheaper foreign counterparts close, leaving a lasting impact on those laid off, their families and the wider region (European Commission, 2017).

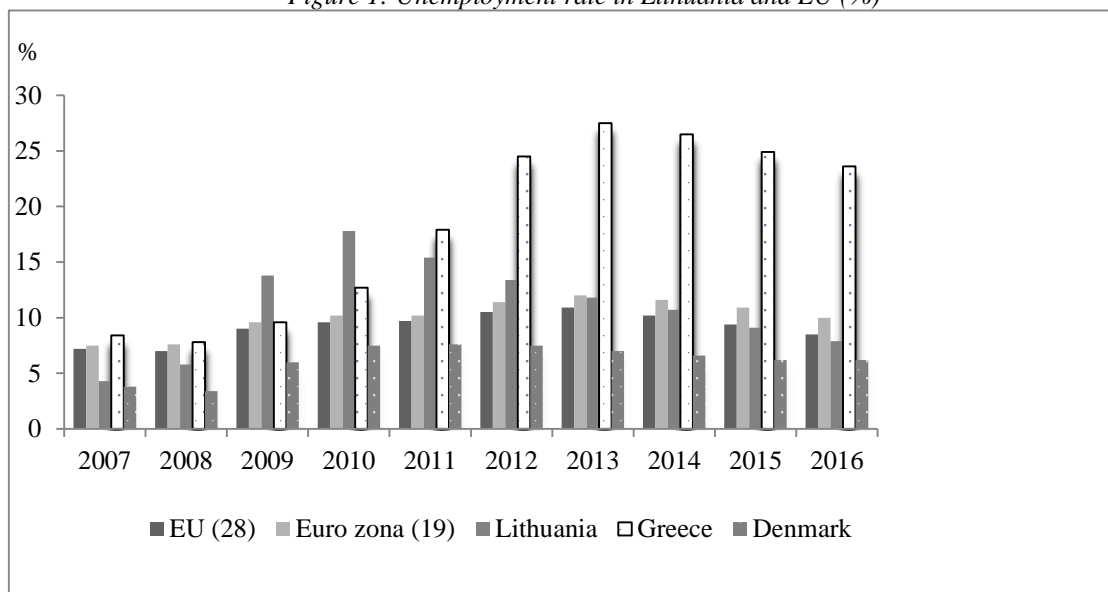
A combination of globalisation and technological change has increased demand for skilled labour but reduced the number of jobs for those with a lower level of qualifications, particularly in manufacturing. Displaced workers struggle to get a new job, especially when this means acquiring new skills. Legal immigration has generally boosted the economies of receiving countries and can provide the EU with the skills needed to address labour market shortages. However, where local infrastructure and integration efforts have not kept pace with the increased scale of migration, this can lead to social tensions in communities. In particular, in

countries and regions with high levels of unemployment and exclusion, economic and societal costs can be high, whilst in some cases marginalisation can also lead to radicalisation.

### 3. Evaluation of employment situation in the conditions of globalization

Evaluation of the employment tendencies in Lithuania in the long- term perspective show that situation in the labour market is tightly related and dependent on cycles of economic fluctuations (Fig. 1).

Figure 1: Unemployment rate in Lithuania and EU (%)



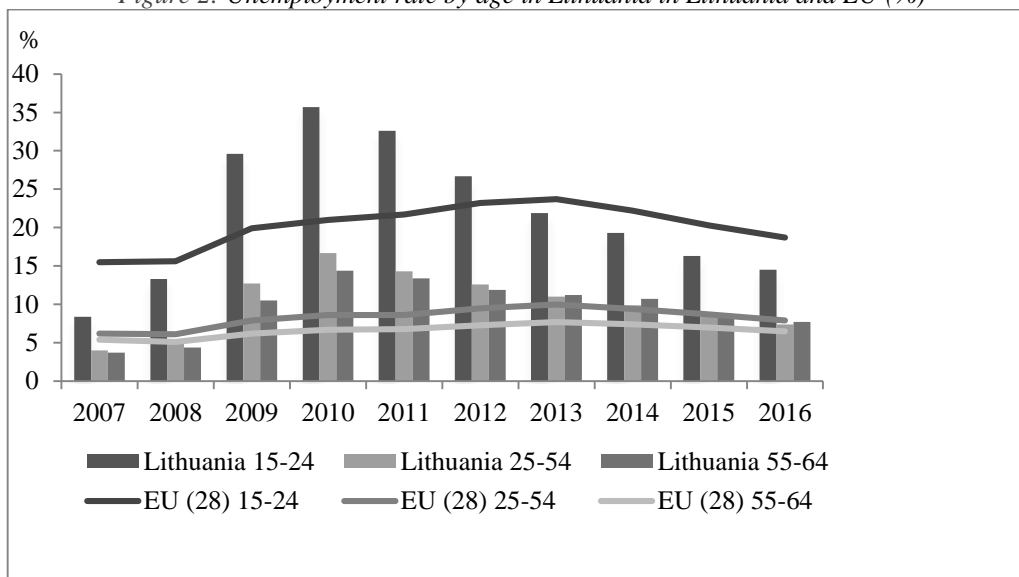
Source: based on Eurostat data

To be emphasized, that global financial crisis together with overheat of real estate market affected Lithuanian labour market more than any other EU countries. The peak of unemployment in Lithuania fixated in 2010 (reached even 17.8 %), significantly exceeded EU (28) median (9.6 %).

Despite improving situation in labour market, neither in Lithuania, nor in European Union (EU 28) the level of unemployment in 2016 did not reach the level before crisis, the indicator remains higher. Eurostat 2016 data show the lowest level of unemployment is in Czech Republic (4 %) and Germany (4.1 %), the highest – in Greece (23.6 %) and Spain 19.6 %). The level of unemployment of young persons is outstanding and much higher in all EU countries (Fig. 2).

The financial crisis of 2009 made severe impact on the employment indicators in Lithuania. In 2010 there were fixated the lowest rate of employment through the period of evaluation. After significant drop, that concluded 10 percentage points, in 2008–2009 employment rate reached 63 % in Lithuania. Starting form 2011 recovery of Lithuanian economy brought back lost opportunities and the indicator started tendentious lift up. When comparing EU 28 and Lithuanian labour average, we can observe that changes in labour were significantly more serious in Lithuania than EU average.

Figure 2: Unemployment rate by age in Lithuania in Lithuania and EU (%)

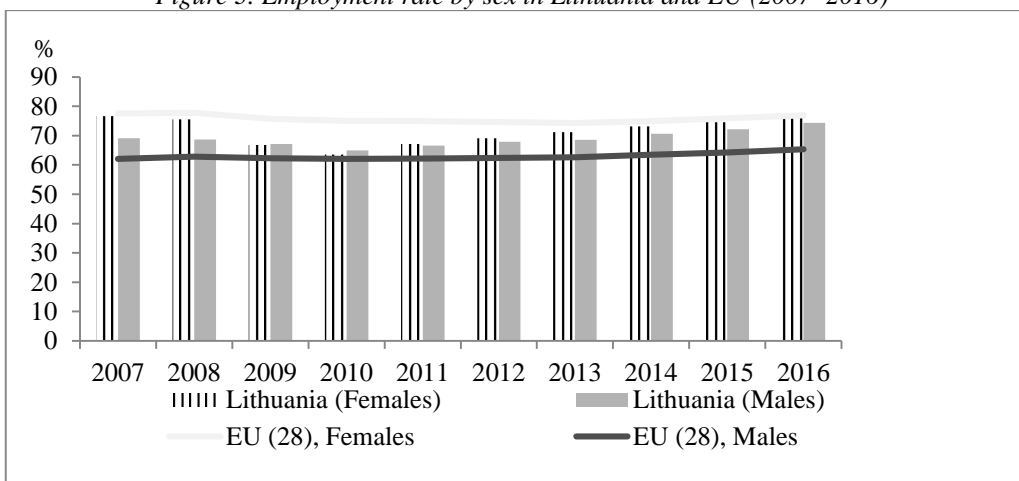


Source: based on Eurostat data

One of the main goals of the strategy „Europe -2020– to reach that till 2020 75 % of all citizens of European Union (at age 20–64) participate in labour market (European Commission 2010). In order to achieve this goal there were recommended to reform out-dated labour market policies of some EU countries. The special attention shall be paid to flexibility of work relations and to life-long learning conception. Statistics Lithuania data show, that in the 2nd quarter of 2016, employment rate among citizens of Lithuania (at age 20-64), exceeded the goal, defined in the strategy, reaching 75.4 % limit, that was higher than EU average.

Analysing employment level in Lithuania according to sociodemographic attributes, traditionally employment level of men is higher than women (Fig. 3).

Figure 3. Employment rate by sex in Lithuania and EU (2007–2016)



Source: based on Eurostat data

Analysis of statistic data shows in 2007–2008 in Lithuania men were employed around 8% more often than women. However, since 2009 this gap is decreasing. There is an assumption that economic recession had bigger impact on young men employment (the employment level in male category declined more than in female). Analysis of EU (28) changes of employment

situation by gender show that during the last 20-year general tendencies are the same (male employment exceeds female employment by 10 %).

This is relevant also to youth employment tendencies. The largest difference between male and female demographic groups was in 2008 when the difference reached 8.3 percentage points. The smallest difference has been fixated in 2009 when financial crises damaged construction and manufacturing sectors, where male employees compound the largest part. During the financial crisis the young male employment rate decreased from 30.1 % to 19.1 % – that is less than 37 percent. Employment rate of young female in the given period decreased from 21.8 % to 17 %, and that is 23 % drop. Therefore, we can make an assumption that economic recession had stronger impact on young male employment changes. To be emphasized, that employment rates of these demographic groups varied differently as well in post-crisis period: female employment decreased till 2011, when male employment bottom was reached already in 2010.

Globalization, Europeanization and related processes created significant changes in migration also in Lithuania. Since 1990 the number of residents living in Lithuania has dropped by 845 thousand people, which constitutes about 23 % of the entire population. Lithuania is attributed to countries, that experience the high emigration. The country is characterized by the highest negative international migration saldo to 1000 inhabitants in comparison to other European Union states.

#### **4. New opportunities and challenges in the Lithuanian labour market**

In 2012 European Commission submitted recommendations to Lithuania in order the Government can effectively implement the program of national reform. One of the items in the recommendations was directed toward actions against high level of unemployment at that time. Not enough flexible labour market policy was underlined as one of the possible limitations. Regarding that, there were recommended to change legal acts, related to conditions of work agreements, terms of dismissal and flexible work forms (European Commission, 2012).

Scientific researches show (Bernal-Verdugo et al., 2012) that reforms of labour market that aim to achieve flexibility of labour market and liberalization of work relations shall lower unemployment level. The flexibility of labour market is treated as necessity that helps countries to adjust to dynamic changes of conditions in globalization circumstances. There is an approach, that work standards and regulation has a negative impact on labour market flexibility and decrease competitiveness on macro – countries and micro – organizational levels (Cook, 2010).

In order to liberalize local labour market, in 2016 The Parliament of The Republic of Lithuania adopted the project of the law, which changed the Labour Code, valid from 2002. The new Labour Code of the Republic of Lithuania aims to create more flexible labour market and therefore more attractive to local and foreign investors.

In European Commission Europe 2020 strategy for smart, sustainable and inclusive growth, the labour market flexibility is presented as the main instrument, enabling members of European Union to induce into labour markets more attractiveness and to reveal potential opportunities for employment for reaching the stated goal.

One of the main novelties, that allows organizations to plan human resources more flexibly and employees to adjust working functions to personal needs, are the new types of employment contracts:

*Temporary employment contract.* That is an employment form where work relations involve three parties – temporary employee, temporary employment enterprise and the user of temporary work. Thus, a temporary employee for the fixed period or non-fixed period is sent to a temporary job at the organization of the user of temporary work. This labour form allows to employ the work force that is not needed in the actual time, without dismissal, and later when situation in the company changes to return employee back.

*Employment contract with not defined work scope.* That is a work agreement, where time for work functions is not set in advance and the employee commits to execute the job functions when the employer asks and informs in advance to five work days. The minimal obligation of the employer is to pay the minimum sum required for 8 work hours per month despite there was or there was not request for a job. The employer is allowed to work at the other work place and is able to refuse in the written form to take a job after the employers' request if requirements of Labour Code Article 86 (Register of Legal Acts, No. 23709, 2016) had been violated and such rejection is not treated as violation of job duties.

*Project employment contract.* That is a terminated employment contract, where the employer commits to execute work duties for the concrete result. The duration of the contract is up to two year period with the new employee and up to five years, if this form of employment changes previous valid employment contract. The Labour Code defines the wage payment order – not lower than a minimal hourly payment and opportunity to additional payment for the executed result.

*Shared workplace employment contract* – under this contract, two employees, share one workplace without exceeding established working time norm. The work time of different employees can be different – that is an item of mutual agreement of the contract parties and has to be approved by the employer and can be changed. Periods of sick leave and leave for one employee do not influence the work schedule and order of the other. When the new contract is signed or the ordinary employment contract is changed into shared workplace employment contract, the employer is obliged to discuss the possibility to apply this form of employment, if manufacturing and organizational process allows and the employee's who requests for this form of employment belongs to the social risk groups.

*Shared employer contract.* This is a contract, signed by the employee and two or more employers. The job function of the employee remains the same. The employee's work time may not be divided for each employer if the employee executes job functions, satisfying need of several employers at the same time. On the contrary, the parties can agree about the work time norms or work schedule in the contract and that shall be presented to the employee, taking over the job functions, not later than five work days in advance. In the employment contract the lead employer is chosen, he by The Labour Code, carries all obligations and all typical employer's functions – taxation of work incomes, designing work schedules, provision of information about the employer and other. Other employers compensate to the lead employer costs, in regard to the work time devoted to them by the employee.

*Seasonal employment contract.* This contract is applied when due to natural and climate conditions (seasonal period) is not possible to offer to employee permanent work and employment. This employment contract defines that employee works during the periods of duration not longer than eight months. The jobs executed under such contracts shall be included into the list of seasonal works. The terms and conditions of the seasonal employment contracts as well payment of wages and other peculiarities are regulated by the Government of the Republic of Lithuania following The Labour Code (Register of Legal Acts, No. 23709, 2016).

Updated reclamation of work relations creates more opportunities to choose adequate work relations form. Employees and employers will be able to react to market and own needs more flexibly. Scientists consider that employment for not full work day has positive impact for country residents as well for the whole economy. Despite increasing work satisfaction, scientists find, that employees, working under flexible employment forms, more often choose to work in simple positions and to receive lower salary, more seldom attend qualification programs and other education

## 5. Conclusions

The analysis of the labour market is inseparable from the outcomes of globalization. High emigration existing in Lithuania is an obvious outcome of globalization. Despite globalization has positive traits, such as free movement, new work places, the rise of technologies and other, as the executed analysis show it also creates a lot of problems: ageing of countries, lack of qualified work force, dishonest business practice of some foreign companies or states. On the other hand globalization is an inescapable process aiming to progress and foster the development of innovations, therefore it is important to establish the right „rules”, in order the business becomes “conscientious”, creating competitive work places, oriented toward principles of sustainable development on macro and on micro levels, supporting economic stability and steady growth of well-being.

European Commission in 2012 recommended to Lithuania relevant changes and solutions for the employment market policy. There is a hope that the new Labour Code of the Republic of Lithuania, adopted in 2016, will give more flexibility to labour market not only in aspects of dismissals and labour disputes, but also will provide significant changes in regulation of employment contracts. New forms of employment contracts shall create more flexibility, that will increase attractiveness of specific demographic groups in the labour market, therefore will foster competitiveness of local business organizations. Employment promotion initiatives that are put into action will create new possibilities for persons willing to participate in the labour market under conditions of globalization.

## References

- [1] Aubry, A., Burzynski, M. and Docquier, F. (2016). The welfare impact of global migration in OECD countries. *Journal of International Economics*, vol. 101, pp. 1–21.
- [2] Bernal-Verdugo, L. E., Furceri, D. and Guillaume, D. (2012). Labor market flexibility and unemployment: new empirical evidence of static and dynamic effects. *Comparative Economic Studies*, vol. 54, no. 2, pp. 251–273.
- [3] Bojnec, S. and Ferto, I. (2017). Effects of globalization and corruption on the outward FDI in OECD countries. *Ekonomický časopis*, vol. 65, no. 3, pp. 201–219.
- [4] Buch, C. M. and Pierdzioch, Ch. (2014). Labour market volatility, skills, and financial globalization. *Macroeconomic Dynamics*, vol. 18, no. 5, pp. 1018–1047.
- [5] Cabral, R., Garcia-Diaz, R. and Varella Mollick, A. (2016). Does globalization affect top income inequality? *Journal of Policy Modeling*, vol. 38, no. 5, pp. 916–940.
- [6] Cook, L. J. (2010). More rights, less power: Labor standards and labor markets in East European Post-communist States. *Studies in Comparative International Development*, vol. 45, no. 2, pp. 170–197.

- [7] Cuyvers, L., De Lombaerde, Ph. and Rayp, G. (2011). The labour market consequences and regionalisation introduction. *International Journal of Manpower*, vol. 32, no. 3, pp. 252–256.
- [8] Davidson, C. and Sly, N. (2014). A simple model of globalization schooling and skill acquisition. *European Economic Review*, vol. 71, pp. 209–227.
- [9] Eurostat Database. [Online]. Available: <http://ec.europa.eu/eurostat/data/database>.
- [10] Fernandez Perez, A. (2016). Problems about migration in the globalization context. *Praxis Sociologica*, vol. 20, pp. 147–166.
- [11] ILO statistics database. [Online]. Available: <http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm>.
- [12] IMF, World Bank, WTO (2017). Making trade an engine of growth for ell. The case for trade and for policies to facilitate adjustments.
- [13] Kurekova, L. and Hejdukova, P. (2016). Globalization and migration: The empirical study of panel data of the migration in the Czech Republic and Slovak Republic. *16th International Scientific Conference on Globalization and its Socio-Economic Consequences*, Rajecke Teplice, Slovakia, pp. 1136–1144.
- [14] Labour Code of the Republic of Lithuania (Legal Acts) XII-2603. TAR (Register of Legal Acts), 2016, no. 23709 (Valid from July 1, 2017).
- [15] Martins, P. S. and Yang, Y. (2015). Globalized labour markets? International rent sharing across 47 countries. *British Journal of Industrial Relations*, vol. 53, no. 4, pp. 646–691.
- [16] OECD (2017). Key issues paper: making globalisation work: better lives for all. [Online]. Available: <https://www.oecd.org/mcm/documents/C-MIN-2017-2-EN.pdf>.
- [17] Recommendation for a Council Recommendation on Lithuania’s 2012 national reform programme and delivering a Council opinion on Lithuania’s convergence programme for 2012–2015. COM (2012) 319 final. Brussels: European Commission.
- [18] *Reflection paper on harnessing globalization*. European Commission. (2017). COM (2017) 2040. ISBN 978-92-79-68226-1. Belgium: Brussels.
- [19] Seo, H. J., Kim, H. S. and Lee, Y. S. (2015). Globalization and labor demand elasticities: Empirical evidence from nine OECD countries. *Korean Economic Review*, vol. 31, no. 2, pp. 413–439.



# GLOBAL RESPONSIBILITY FOR THE QUALITY OF ELECTRICITY

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**Abstract.** Electricity, being a market product, must have certain parameters. Providing these parameters is mainly supplier's responsibility. However, it turns out that the electricity quality indicators provided by the supplier are significantly affected by the consumers themselves. In the past, large industrial plants caused the biggest disruptions in the power system. Particularly steelworks with electric arc furnaces and with unit power of up to dozens MW generated disturbances experienced by many consumers of electricity. Interference in the power grid generated by the furnace had a direct impact on man through the light sources. In recent years the nature of used receivers has changed significantly, especially those used by individual consumers. For example, a whole range of modern electronic devices has appeared in households. Recently LED technology has gained popularity. The following article is continuation of the issues related to power security and electricity quality presented at the 16th International Scientific Conference on Globalization and Its Socio-Economic Consequences. This article will present the impact of large industrial customers on energy quality. It will try to trace the direct influence to the human organism caused by interference generated to the power grid by receivers installed in the steelworks. Another issue will be addressing the problem of global "littering of the power grid" by individual consumer.

**Keywords:** costs of poor power quality, flicker of light, disrupting of the power grids

**JEL Classification:** L49, Q40, Q41, Q43

## 1. Introduction

Electricity produced in commercial power plants is characterised by very good quality parameters. Voltage is symmetric, without distortions, ideally sinusoidal. The supply of electricity with appropriate quality parameters on a continuous basis is a very complex issue. Ensuring continuous power supply and issues relating to long power supply interruptions were presented at the 16th International Scientific Conference Globalization and Its Socio-Economic Consequences (Olczykowski & Łukasik, 2016), (Korczak et al., 2016) This paper mainly focuses on the electricity quality. What is poor electricity quality, who causes its deterioration, and what are its consequences? An answer to such questions will be presented in its further part.

## 2. Electricity quality indicators

The rated voltage of a low voltage grid is 230/400V. Due to a variable load, disturbances occurring in the grid, technical condition of a line, etc., the voltage changes in a more or less dynamic way: voltage fluctuations, voltage dips, interruptions, overvoltage. These changes

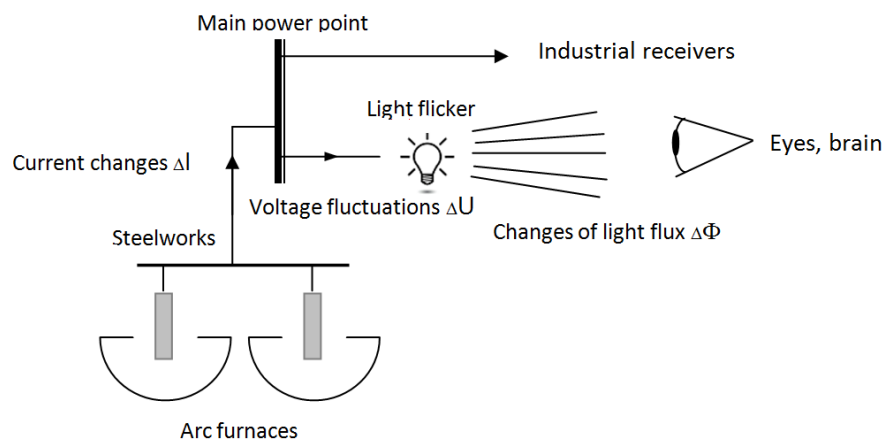
affect both the value and the shape of voltage curve. Considerable voltage deviations from its rated value and sinusoidal shape may cause disturbances in the power grid operation as well as industrial and individual receivers. Therefore, regulations have been adopted, which regulate the voltage quality supplied to its consumers. A legal act enforced in Poland in respect of electricity is the Regulation (Ordinance of the Minister of Economy, 2007). It has been considerably based upon the EN-50160 (Parameters of the supply voltage ..., 2014).

Basic indicators characterising electricity quality include: supply voltage root mean square and a range of its fluctuations, voltage frequency and a range of voltage frequency fluctuations, long-term flicker severity value  $P_{lt}$ , supply voltage asymmetry factor, Total Harmonic Distortion summary, percentage factor THD, percentage content of individual harmonics  $u_{h\%}$ , a summary supply interruption time during a year, a single supply interruption time.

### 3. Reasons for poor electricity quality

It may be assumed that electricity produced in commercial power plants meets all requirements stipulated in norms and regulations. It is transmitted by transmission and distribution lines to consumers. During the transmission some disturbances may occur affecting the continuity and quality of electricity. They can be divided into three groups. The first group comprises external factors, independent of commercial power industry. These are, inter alia, weather conditions: storms, hurricanes, icing, floods, etc. They affect mostly power supply dependability (power supply interruptions). The second group of disturbances comprises disruptions resulting from commutation operations within power grids, causing mostly over voltages and voltage dips. The third group of disturbances is dependent on the technical condition of transmission and distributions networks. The poor condition of a network causes considerable low voltage failures and power supply interruptions.

Figure 1: Light flicker perception



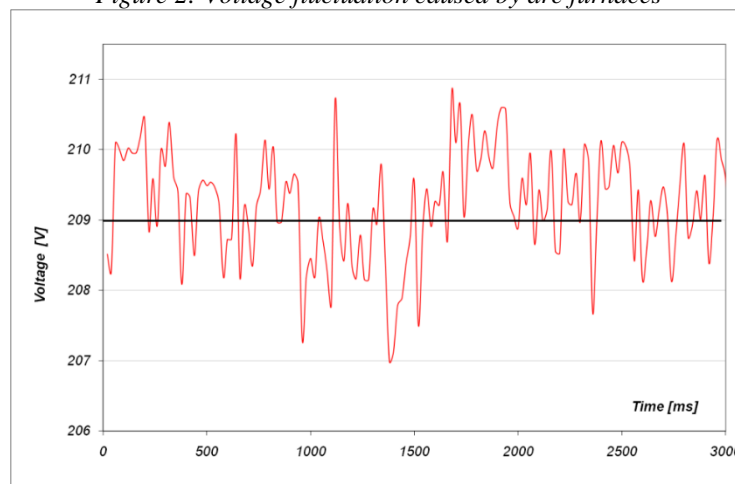
Source: (Own elaboration)

A significant influence upon the quality of electricity within a power grid is exerted by consumers operating arc devices, predominantly electric arc furnaces. Arc furnaces belong to the biggest receivers supplied from the power grid. The technological process related to the melting of steel is characterised by rapid fluctuations of the current consumed by the furnace. Arc furnaces, similarly to arc welding machines, cause the occurrence of high-frequency voltage fluctuations. The fluctuations result in light flicker, which has a direct impact on a human being. It may lead to problems with concentration, mistakes in professional work (precision mechanical engineering, watchmakers' work, etc.), and in extreme cases, it may

cause epilepsy recurrences. The indicators which inform us about the adverse effect of light flicker are: short-term flicker severity value  $P_{st}$  and long-term flicker severity value  $P_{lt}$ . The Fig. 1 shows the process of flicker caused by the operation of arc furnaces.

Light sources are among the receivers which are very vulnerable to even small voltage fluctuations, which disturb their operation (Alkandari & Soliman, 2009). Voltage fluctuations can be defined as interharmonics (Maksic & Papic, 2012). Those disturbances are perceptible to a human being as light flicker. The Fig. 2 shows voltage fluctuations caused by arc furnaces.

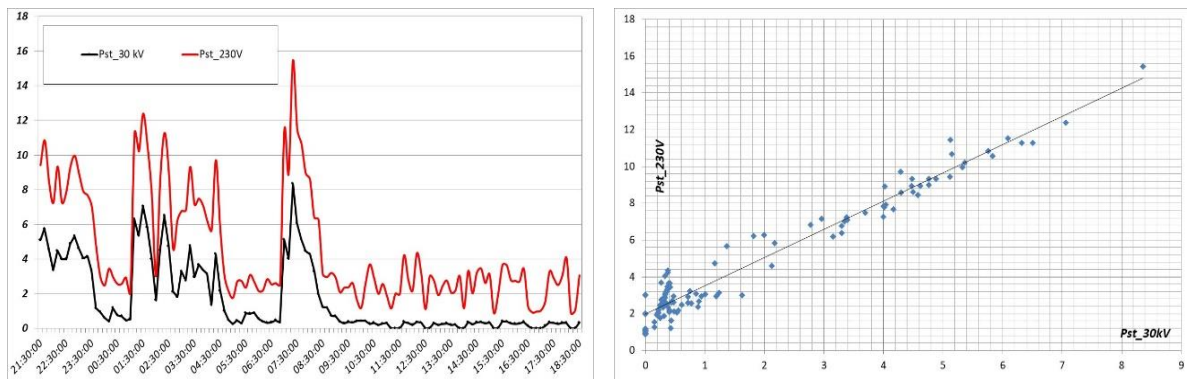
Figure 2: Voltage fluctuation caused by arc furnaces



Source: Own measurements

An experiment was carried out during the research conducted by the author. Its purpose was to determine an extent to which arc furnaces influence light flicker. Lighting receivers in a mill were powered from the same transformer as arc furnaces. In normal conditions, receivers vulnerable to voltage fluctuations are powered from a different, independent transformer. Fig. 3 shows changes in light flicker indicators measured simultaneously in the steel mill power supply network ( $U_n=30\text{kV}$ ) and in the lighting system of steel mill office facilities ( $U_n=230\text{V}$ ). During the arc furnace operation between 9:30 p.m. and 9:30 a.m., an increase in light flicker could be observed. Particularly high values occurred at the initial stages of the melting process. The disturbances caused by the arc furnace were transmitted via power supply lines and the main transformer of the mill to the lighting circuits. The correlation coefficient between the light flicker within the 230V lighting system and the 30 kV steel mill power supply network is 0.98 (Fig. 3).

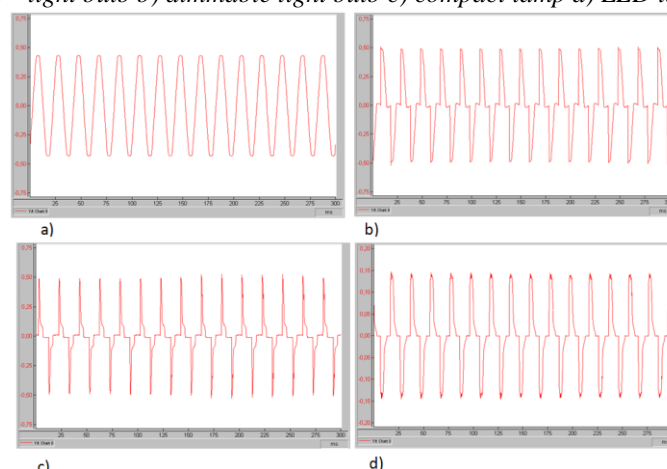
Figure 3: Changes in light flicker indicators measured simultaneously within the steel mill power supply network and lighting system of steel mill lighting facilities.



Source: Own measurements

From among lighting receivers, incandescent light sources belong to devices being most vulnerable to voltage fluctuations. Due to low energy performance in the European Union member states, light bulbs have been being withdrawn from the market since 1 September 2009 (Commission Regulation (WE) NR 244, 2009). Energy-saving compact lamps, halogen lamps, and recently lamps made in LED technology widely introduced into the market, have allowed to revolutionise lighting technology. The introduction of modern light sources has considerably decreased energy consumption as well as reduced light flicker resulting from voltage fluctuations. Modern lighting devices, on the one hand, reduce energy consumption, but on the other hand, cause its quality to deteriorate. The use of energy-saving compact lamps, halogen lamps powered by electronic transformers, electronic dimmers or LED light sources causes energy quality disturbances (Sohel et al., 2013), (Yi et al., 2014). Single receivers have small unit power. However, their common use creates serious problems for the whole power grid. The Fig. 4 shows currents consumed by a light bulb, a light bulb controlled with a dimmer, a compact lamp and an LED lamp.

Figure 4: Currents consumed by light sources  
 a) light bulb b) dimmable light bulb c) compact lamp d) LED lamp



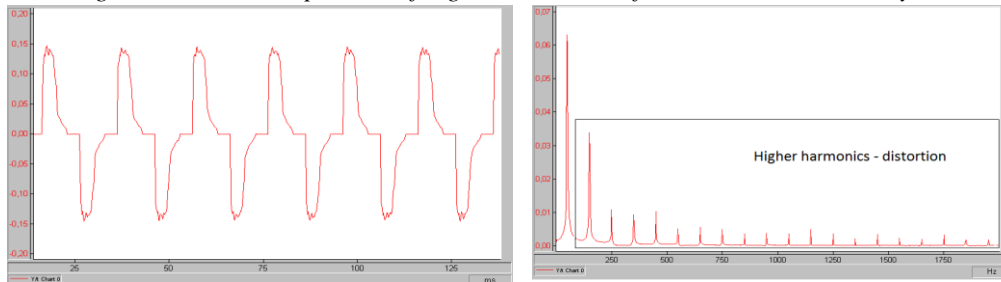
Source: Own measurements

The current consumed by a light bulb is sinusoidal. The currents consumed by the other receivers are non-linear, are considerably distorted. One of the consequences of non-linear

current flow is a power grid voltage distortion. The voltage distortion causes a great number of adverse phenomena with regard to both devices comprised by the power system and receivers operated by industrial and individual consumers.

The Fig. 5 shows the flow of a current consumed by an LED lamp and its spectrum of higher harmonics.

Figure 5: Flow and spectrum of higher harmonics of the current consumed by LED lamp

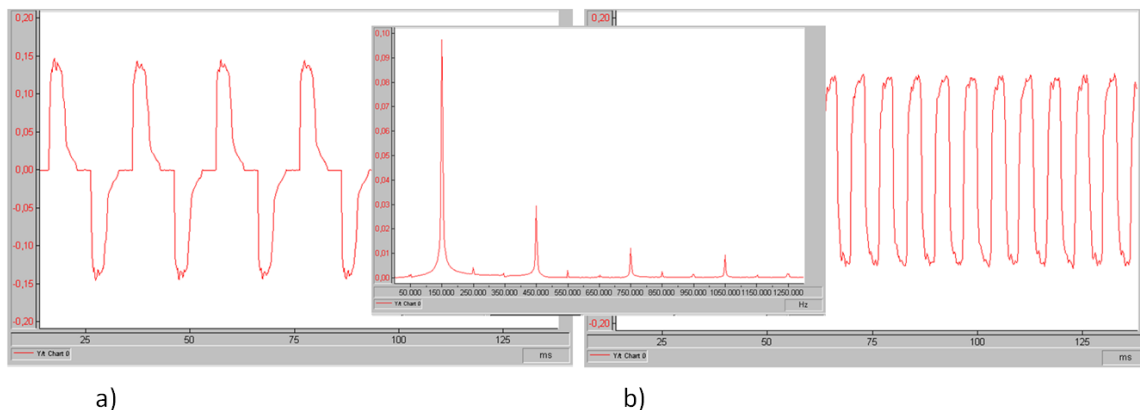


Source: Own measurements

One of the consequences of the flow of distorted currents in electrical systems is an increase in the current in a neutral conductor. At symmetric linear load with e.g. light bulbs, the current does not flow in the neutral conductor.

The Fig. 6 shows the flow of a current in the phase conductor as well as total current in the neutral conductor. It is an example of three-phase power supply of a symmetric non-linear lighting system (compact lamps). In the case of a symmetric non-linear system, the higher harmonics of a current being multiplicity of three, are summed up. The current in the neutral conductor may exceed the value of phase currents.

Figure 6: The flow of a current in the phase conductor (a) and the total current in the neutral conductor (b)



Source: Own measurements

For a three-phase symmetric receiver consisting of compact lamps, the current in a neutral conductor is 147% of the phase current, whereas 137% in LED lamps and 133% in dimmer-powered light bulbs.

#### 4. Costs of power supply interruptions and poor electricity quality

Electricity, as a product which is sold to industrial, municipal, individual, etc., must be characterized by certain parameters. Failure to ensure such parameters results from disturbances occurring within a power grid and power devices as well as receives used by consumers.

A power supply interruption is a disturbance which is always noticeable to consumers. A power supply interruption may last from a few milliseconds to a few days. In the event of long interruptions affecting a vast area and a considerable number of consumers, we deal with the so-called Blackout (Bialek, 2010).

Costs of the most serious power grid failures run into billions dollars (Andersson et al., 2005; van der Vleuten & Legendijk, 2010). The most severe power failure in Europe, which took place 28 September 2003 in Italy from affected 35 million of inhabitants. The costs of the failure were estimated to reach over 2,3 billion euro (Corsi & Sabelli, 2004), (Petracci, 2011). A powerful failure took place in North America in the same year. It affected over 50 million consumers in the USA and Canada. The costs were estimated to be approx. 8-10 billion dollars (Hines et al., 2009). In 30-31 July 2012, over 700 million of citizens of India were deprived of electricity supply.

Not only long power supply interruptions cause considerable financial losses. It turns out that more than 95% power supply disturbances occurring within a power system are represented by voltage dips and short power supply interruptions. It is estimated that power quality problems cost industry and commerce in the EU about 10 billion per annum while expenditure on preventative measures is less than 5 % of this. Table 1 shows costs dependent on the type of a consumer and the duration of a power supply interruption (Chapman, 2001).

Table 1: Typical financial loss

Factory	Cost [Euro]	Time
Semiconductor production	3 800 000	per event
Financial trading	6 000 000	per hour
Computer centre	750 000	per hour
Telecommunications	30 000	per minute
Steel works	350 000	per minute
Glass industry	250 000	per minute

Source: Chapman, D. 2001

Considerable costs are incurred by industrial consumers, who must limit disturbances they generate. For instance, reduction of voltage fluctuations (resulting in light flicker) caused by arc furnaces, by means of SVC\_Light devices represents costs amounting to approx. 60% of the whole furnace system. The use of passive and active filters restricting an impact of higher harmonics means additional costs to be incurred by consumers operating receivers generating those disturbances.

It turns out that the introduction of receivers which were to save electric energy into the market causes a number of disturbances within the power system. Examples of such receivers are energy-saving compact lamps and light sources made in LED technology. Based on the research conducted by the author, those receivers generate higher harmonics into the power grid. Due to the small unit power of individual receivers reaching up to a few watts, disturbances generated by individual devices are small. However, the common use of those receivers causes the disturbances to sum up. As a consequence, a considerable amount of small disturbances enters the power system, which ultimately causes serious financial losses. In the event when only nonlinear currents flow through a transformer, its throughput decreases by more than 50% as compared with the flow of sinusoidal currents. The capacity of line and

power devices decreases likewise. Voltage higher harmonics (voltage distortions) also affect correct operation and life-span of electricity receivers.

## 5. Conclusion

The paper focuses mostly on two types of disturbances occurring within a power system. The first are high-frequency voltage fluctuations resulting in light flicker. This type of disturbances is mostly caused by receivers with a dynamically changing load. Light flicker is directly perceptible to a human being. Depending on the intensity of voltage fluctuations, the adverse effect of flicker may be more or less bothering. Reduction of light flicker sensibility can be gradually achieved by the introduction of modern light sources. It turns out, however, that the use of compact lamps or LED lamps entails another type of disturbances. These are higher harmonics (the second type of disturbances described in the paper) generated into power grids. They cause a number of disturbances in the operation of lines and receivers.

Arc devices, particularly arc furnaces, cause disturbances which affect a considerable number of consumers. Similarly, disturbances caused by modern light sources are a global problem for domestic power systems. Elimination of those disturbances involves considerable costs. In the case of arc devices, the costs of reducing disturbances, particularly voltage fluctuations, are incurred by consumers (mills). Reduction of higher harmonics generated by nonlinear receivers of small unit power, including modern light sources, is more complex.

Supplying consumers with energy characterised by certain parameters on a continuous basis is a very complex issue. The list of the causes of the poor electricity quality supplied to consumers is very long. It may start from disturbances independent of energy suppliers and connected with extreme weather conditions, through the bad technical condition of a network and end up with interfering receivers used by consumers.

So what remedial measures should be taken? Firstly, a wide information campaign should be conducted on the issue of electricity quality. One of the Polish organisations dealing with this issue is the Electric Energy Quality and Effective Use Committee operating at the Association of Polish Electrical Engineers (SEP). Education of future electrical engineers by running studies focusing on the issue of energy quality.

## References

- [1] Andersson, G., Donalek, P. et al. (2005). Causes of the 2003 major grid blackouts in North America and Europe, and recommended means to improve system dynamic performance. *IEEE Transactions on Power Systems*, vol. 20, pp. 1922-1928.
- [2] Alkandari, A. M. and Soliman, S. A. (2009). Measurement of a power system nominal voltage, frequency and voltage flicker parameters. *Electrical Power and Energy Systems*, vol. 31, pp. 295-301.
- [3] Bialek, W. J. (2010). Critical interrelations between ICT and electricity system. *Securing Electricity Supply in the Cyber Age*, Springer, pp. 53-70.
- [4] Chapman, D. (2001). The cost of poor power quality. *Power Quality Application Guide – Cost. 2.1. Copper Development Association, European Copper Institute*.
- [5] Corsi, S. and Sabelli, C. (2004). General blackout in Italy Sunday September 28, 2003, h. 03:28:00, *IEEE Power Engineering Society General Meeting*, vol. 1 and vol. 2, pp. 1691-1702.

- [6] Hines, P., Apt, J. and Talukdar, S. (2009). Large blackouts in North America: Historical trends and policy implications. *Energy Policy*, vol. 37, pp. 5249–5259.
- [7] Korczak, A., Olczykowski, Z. and Wojciechowski, J. (2016). The smart grid technology in Poland as a part of global electric power system. *16th International Scientific Conference Globalization and Its Socio-Economic Consequences*, Rajecke Teplice, Slovakia, pp 945-953.
- [8] Maksic, M. and Papic, I. (2012). Calculating flicker propagation in a meshed high voltage network with interharmonics and representative voltage samples. *Electrical Power and Energy Systems*, vol. 42, pp. 179–187.
- [9] Olczykowski, Z. and Łukasik, Z. (2016). The impact of blackouts on the economy and national security. *16th International Scientific Conference Globalization and Its Socio-Economic Consequences*, pp – 1596 -1603.
- [10] Petracci, B. (2011). Trading when you cannot trade: Blackout periods in Italian firms. *International Review of Law and Economics*, vol. 30, pp. 196-204.
- [11] PN-EN 50160:2014: (2014). Parametry napięcia zasilającego w publicznych sieciach elektroenergetycznych. *Warszawa, Polski Komitet Normalizacyjny*. [In Polish: PN-EN 50160:2014 Parameters of the supply voltage in the public power networks, Warsaw: Polish Committee of Standardization].
- [12] Rozporządzenie Ministra Gospodarki z dnia 4 maja 2007 r. w sprawie szczegółowych warunków funkcjonowania systemu elektroenergetycznego (2007). *Dz. U. Nr 93, poz. 623*, [In Polish: Ordinance of the Minister of Economy of 4 May 2007 on detailed conditions for the functioning of the power system. 2007. Dz. U. Nr 93, poz. 623]
- [13] Rozporządzenie Komisji (WE) NR 244/2009 z dnia 18 marca 2009 r. w sprawie wykonania dyrektywy 2005/32/WE Parlamentu Europejskiego i Rady w odniesieniu do wymogów dotyczących ekoprojektu dla bezkierunkowych lamp do użytku domowego, *Dz.U. L 76 z 24.3.2009*.
- [14] Sohel, U., Hussain, S. and Azah, M. (2013). Power quality performance of energy-efficient low-wattage LED lamps. *Elsevier Measurement*, vol. 46, pp. 3783–3795.
- [15] van der Vleuten, E. and Legendijk, V. (2010). Interpreting transnational infrastructure vulnerability: European blackout and the historical dynamics of transnational electricity governance. *Energy Policy*, vol. 38, pp. 2053–2062.
- [16] Yi, L., Gyung-Seok, H. and Hee-Jun, K. (2014). Analysis of the twice-line-frequency light flicker of an LED lamp driven by a single-stage PFC Circuit. *Journal of the Korean Physical Society*, vol. 65, no. 2, pp. 234-238.