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ROLE OF RENEWABLE ENERGY SECTOR IN SPECIFIC EUROPEAN UNION STATES, WITH PARTICULAR FOCUS ON POLAND

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At present, the energy from renewable sources is an important element of the sustainable development strategy of the European Union (strategy covering the period until 2020). The article presents the role of renewable energy in the structure of primary energy sources and total energy production. In order to evaluate the present-day role of the renewable energy sector, specific European Union states were analysed, with particular focus on Poland, the country whose results were juxtaposed with the average ratios established for the EU-28. A detailed analysis of the current facts was performed (also a forecast for the period running up to 2020 was made), where particular energy sources were distinguished in the renewable energy production structure. A special role among renewable energy sources was ascribed to solar energy, wind energy, hydropower, geothermal energy, biogases and biofuels. The conclusions drawn from the research point out to the fact that the development of renewable energy in Poland is growing slowly but surely. In 2011, the share was at 9.5% and by 2015 it grew to 11.8%, with the target set for 2020 being at the level of 15.0%. The production of energy from renewable sources is improving (from 7.5 to 8.1 Mtoe). Nevertheless, the share of primary energy obtained from renewable energy sources in the total primary energy is less than half of the EU share. The data showcase that the projected aim is likely to be achieved; however, the few years to come should envisage some intensification of activities oriented to this goal. Biomass now enjoys the dominant role but its significance is gradually waning, which favours wind energy and biofuels. The projected directions of renewable energy development indicate that this sector is going to be a significant factor in implementing the sustainable development policy in the years to come.

Keywords: European Union, Poland, renewable energy sector

INTRODUCTION

The main reason for increasing the significance of renewable energy sources (RES) in the energy policy for the European Union states is the provision of energy security through diversification of energy supplies and decentralisation of energy production. It is also important to stimulate the creation of new work places in this sector, which is to include rural areas as well. Moreover, the development of renewable energy sources subscribes into the plan of establishing the low-carbon economy for the EU (Pach-Gurgul, 2014; Energy..., 2016). What comes as a vital element here is the ecological aspect, i.e. minimisation of unfavourable impacts on the natural environment, e.g. by reducing emissions of harmful substances to the atmosphere. The use of renewable energy keeps in check the demand for conventional raw materials, such as: natural oil, gas and coal. In the light of the above, the European Union has accepted the obligation to increase the share of renewable energy sources in the total energy balance in the EU up to 20% until 2020 (Resch et al., 2008; European Commission, 2009). In October 2014, the Council of the European Union set the target for the share of RES in the gross energy consumption in the EU at the level of 27% to be reached by 2030. Individual Member States were not ascribed their role in achieving this target (Doukas et al., 2017).

The renewable energy sector is based on the use of hydropower, geothermal energy, wind energy, biomass, biogas, biofuel and solar energy. The advantage of renewable energy sources lies in the fact that these are local sources and the problem of their exhaustion is non-existent. An increase in the significance of RES may potentially affect the sustainable development, ensuring the balance of the economic, social and natural systems (Varun, Prakash, Bhat, 2009; Stigka et al., 2014). From the economic perspective, it is important to become independent from conventional energy sources and imported fuels, which should contribute favourably to the national energy security. What should be additionally appreciated here is the possibility to receive financial support from the European Union budget dedicated for pro-

ecological activities and promotion of pro-ecological and innovative countries (Haas et al., 2011). Production of biofuels, for instance, allows for the exploitation of highly-contaminated soils unfit for cultivation of edible plants in agrarian areas (Jasiulewicz, 2007). Social advantages include: activation of local communities and creation of new work places, especially in rural areas (Longo et al., 2008). According to Stigka, Paravantis and Mihalakakou (2014) the market of renewable energy provides more work places than that of conventional energy. The most important characteristic of renewable energy, when on the subject of natural environment, is the conservation of natural resources, deceleration of the exploitation of non-renewable energy sources (the concept of decarbonised economy) and reduction in carbon dioxide emissions to the atmosphere. As such, it has a salubrious effect on the natural environment and helps curb or halt the ongoing climate changes (Lehr et al., 2008). On the downside, the renewable energy sector changes the aesthetics of the landscape and introduces there such unattractive constructions as wind turbines or solar panels (Zoellner et al., 2008).

Renewable energy means the energy coming from natural, repetitive, environmental processes, obtained from renewable, non-fossil energy sources, i.e. water, wind, solar radiation, waves, sea currents and tides, and the energy derived from solid biofuels, biogas and liquid biofuels. Renewable energy sources (RES) constitute an alternative to traditional, primary, non-renewable energy-generating products (del Rio, Burguillo, 2016). Solid biofuels comprise organic, non-fossil bio-substances which may be used as fuel to produce heat or generate electrical power. Firewood is the basic biofuel; it comes in form of billets, logs, woodchips, briquettes, pellets, and forestry waste material (branches, brushwood), as well as wood industry waste material (shavings, sawdust) and paper industry waste material (black liquor). A separate group is made up of fuels coming from plantations of energy crops (fast-growing trees, dicotyledonous perennials, perennial grasses, cereals grown for energy production) and organic waste from agriculture and horticulture (Nunes, Matias, 2017). Biogas is the gas obtained from flammable gases; it is mostly composed of methane and carbon dioxide and produced in the process of anaerobic biomass fermentation (Weiland, 2010). Hydropower (potential and kinetic) is defined by the amount of electrical energy produced in hydropower plants. Here, what counts as renewable energy is only the production of electrical power in the power plants naturally fed with water (Hawkins et al., 2003). Wind energy is the kinetic energy used to produce electrical power in wind turbine farms. As is the case with hydropower plants, the potential of wind turbine farms is determined by their capacity to generate electrical power (Burton et al., 2011). Geothermal energy is the heat obtained from the depths of the Earth in form of hot water or steam. Geothermal energy is used directly for household heating, for the purposes of agricultural production, as well as for electrical power production (Boyle, 2004). Renewable energy sources include also refuse derived fuels which are obtained from flammable industrial and household waste, such as: rubber, plastics, waste mineral oil and other similar product waste. They are in the solid or liquid state and are categorised as renewable or non-renewable fuels, depending on their biodegradability.

Poland's accession to the European Union necessitated some adjustments in the national energy policy in order to make it compliant with European guidelines. In 2005 two main renewable energy sector support mechanisms were implemented: the obligation to purchase a specified amount of energy derived from RES, and a system of certificates of origin, the so-called 'green certificates'. The aim of this study is the evaluation of the present-day role of the renewable energy sector in the EU, with particular focus on Poland.

MATERIALS AND RESEARCH METHODS

The article presents the significance of renewable energy in the structure of primary energy sources and total energy production. For these purposes specific European Union states were analyses, with particular focus on Poland, and the results for these countries were juxtaposed with the average ratios established for the EU-28. A detailed analysis of the current facts was performed; also a forecast was made with regard to changes in the renewable energy production structure, including specific kinds of energy. A special role among renewable energy sources was ascribed to solar energy, wind energy, hydropower, geothermal energy, biogases and biofuels. This publication is "resultant statistical information" containing data on energy from renewable sources. This information was obtained as part of statistical surveys of official statistics. The study is based on the comparative analysis of the data (2004-2014) compiled by Eurostat and the Central Statistical Office of Poland [GUS] in Warsaw. Method was used descriptive and comparative studies and the results are presented in graphical form.

RESEARCH RESULTS

The range of use of renewable energy sources in the Member States of the European Union is regulated by relevant documents and normative acts of the European Community (EC). Pursuant to the Energy and Climate Package (adopted in 2008), until 2020 the EU Member States are obliged to:

- increase the share of renewable energy sources up to 20% in the total energy balance of the EU,
- reduce CO_2 by 20% relative to the emission level as of 1990,
- reduce the total consumption of primary energy in the EU by 20% relative to the basic forecast for 2020 presented in 2007,
- increase the share of biofuels up to 10% in the total consumption of fuels in transport across the EU (National…, 2013; Chalvatzis, Hooper, 2009).

In Poland the implementation of the RES-promoting energy policy is to be based on the use of the most economically and ecologically efficient sources, provided there will be no excessive rise in energy prices at the consumers' end. The development of the RES sector is effectuated in the following areas: electrical power, heat and cooling from renewable sources, bio-components used in liquid fuels and liquid biofuels. Energy from renewable sources

comprises the energy derived directly from: solar radiation, wind, geothermal sources, water sources, solid biomass, biogas, and liquid fuels (Koruga, 2011).

Following the general assumptions, by the end of 2020 Poland is to have increased the use of RES up to 15% (Pach-Gurgul, 2012). The EU Member States may receive financial support for investments related to renewable energy financed from national sources or European funds. Common for all the Member States, there is a generally defined obligation to undertake activities promoting the demand for electrical power derived from renewable energy sources, and to issue documents specifying the source of renewable energy. In Poland, financial support is available, for example, from national sources (National Fund for Environmental Protection and Water Management, Voivodship Funds for Environmental Protection and Water Management) and from EU funds (2007-2013 and 2014-2020 operational programmes (OP): Infrastructure and Environment OP, Innovative Economy OP, Smart Growth OP) (European Commission, The EU..., 2017).

In the European Union the significance of renewable energy in the total energy balance is gradually increasing. This situation is mostly affected by ecological arguments, considerations of energy security, as well as the Energy and Climate Package accepted in March 2008. In 2011, the overall energy demand in the EU, expressed as the gross energy consumption, was satisfied in the following fashion: natural oil (34%), natural gas (24%), coal (15%), nuclear power (14%), and renewable energy sources (13%). It is worth emphasising that until mid-2011 the EU was the global leader in the development of renewable energy sources and made more financial allocations for this purpose than China or the USA (Challenges..., 2013).

The analysis demonstrated that the highest share of renewable energy in the total energy balance (as of 2015) was recorded in Sweden (53.9%), which was followed by Finland (39.3%), Latvia (37.6%), and Austria (33.0%). Moreover, Sweden was the first country to exceed the target set in the Energy and Climate Package for 2020. It achieved that as early as in 2011, when the share of renewable energy in the national energy balance was at 49.1% (EU Energy…, 2013). Poland also witnesses progress in the indexes for RES; however, the changes are happening slightly less rapidly. In 2011, the share was at 9.5% and by 2015 it grew to 11.8%, with the target set for 2020 being at the level of 15.0%.

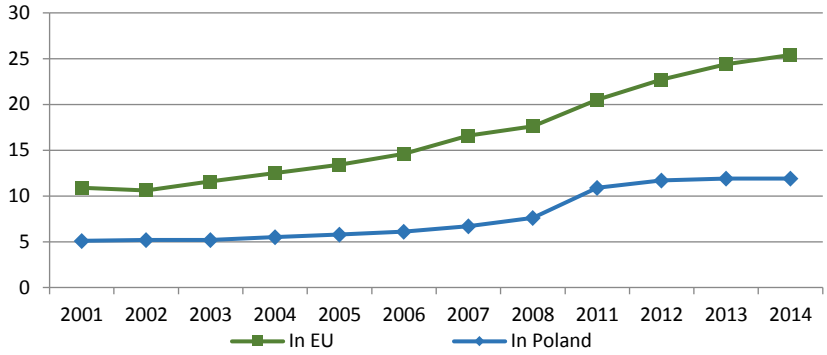
By 2015 there were 11 states (out of 28 in the EU) that exceeded the target set in the Energy and Climate Package (including, e.g. Lithuania with 25.8% against the projected 23.0%). Other 6 states are approaching their targets (they are approx. 1-3% below their limits). The rest of the states (11) should intensify their efforts to accelerate work on the development of renewable energy. That applies in particular to: Netherlands (8.2% below the projected target), France (7.8%), Ireland (6.8%), UK (6.8%), or Belgium (5.1%). Additionally, these countries, except France, have limits set below the EU-28 average (20%). The share of renewable energy in energy production varies widely across the Member States due to different geographical conditions (presence of and access to natural resources), technological progress and political factors (requirements related to decarbonisation and development of internal market).

Table 1. Prospects for the development of renewable energy sources in the European Union by 2020

Country	The share of renewable sources (%)		The target set in the energy and climate package (%)
	2011	2015	2020
UE-28	*12.7*	*16.7*	*20.0*
Austria	30.0	33.0	34.0
Bulgaria	13.8	18.2	16.0
Czech Republic	9.4	15.1	13.0
Denmark	22.2	30.8	30.0
Estonia	24.3	28.6	25.0
Finland	33.0	39.3	38.0
France	13.5	15.2	23.0
Germany	11.0	14.6	18.0
Italy	10.4	17.5	17.0
Latvia	32.6	37.6	40.0
Lithuania	19.7	25.8	23.0
Netherlands	3.8	5.8	14.0
Poland	9.5	11.8	15.0
Portugal	24.6	28.0	31.0
Romania	23.6	24.8	24.0
Slovak Republic	9.8	12.9	14.0
Sweden	49.1	53.9	49.0

Source: own elaboration based on: Eurostat; GUS (Energy ..., 2016); Challenges ..., 2013

The amount of primary energy obtained (totally, including RES) in the period of 2011-2014 illustrate a downward trend in the EU states (from 802.2 to 770.7 Mtoe). Simultaneously, there was a gradual rise in the production of energy from renewable sources (from 164.3 to 195.8 Mtoe), which made its share in the total energy balance more sizeable. At the same time, the primary energy production in Poland fell slightly, i.e. from the level of 68.8 Mtoe in 2011 to 68.2 Mtoe in 2014 (with a periodical growth in the years 2012-2013 (approx. 72 Mtoe). Slowly but surely, the production of energy from renewable sources is improving (from 7.5 to 8.1 Mtoe). Nevertheless, the share of primary energy obtained from renewable energy sources in the total primary energy is less than half of the EU share (fig.1).

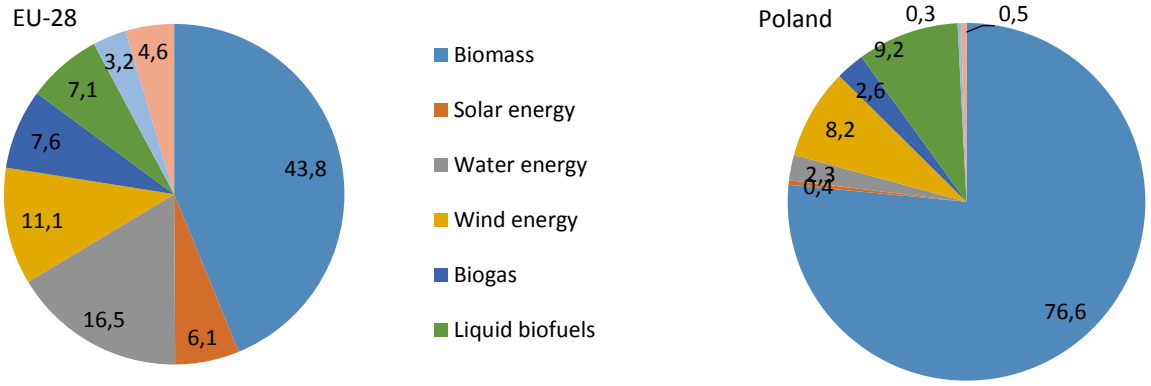


Source: own elaboration based on data: Eurostat; GUS (Energy…, 2016)

Figure 1. The share of renewable sources of energy in total primary energy (%)

In the last decade a remarkable rise was observed in the significance of renewable energy in the gross energy consumption in particular EU-28 states. As can be concluded from the data compiled by Eurostat and the Central Statistical Office in Warsaw, Sweden takes the leading position in the use of renewable energy sources, with the result of 53.9% of the energy consumption (2015). Noteworthy is the fact that the share is even larger in two non-EU states: Norway (69.4%) and Iceland (70.2%). Apart from Sweden, the following countries boast leadership in renewable energy production: Finland (39.3%), Austria (33%), Latvia (37.6%), and Denmark (30.8%). Far above the EU-28 average there are also two other Baltic states: Estonia (28.6%) and Lithuania (25.8%). Poland sees the share below the EU average, with 11.8%. The share of renewable energy in the gross energy consumption differs significantly in individual EU states and is the outcome of the initially dissimilar level of RES consumption in particular countries. Between 2004 and 2015 the highest growth was recorded in Denmark (+15.9%) and Sweden (+15.2%), followed by Italy (+11.2%), Austria (+10.4%), Estonia (+10.2%), Finland (+10.1%) and Hungary (+10.1%). In Lithuania the growth approximated the EU average (+8.2%) and amounted to (+8.6%), while in Poland it was at the level of (+4.9%).

Due to different geographical and climatic determinants, legal conditions and preferred approaches to the development of specific renewable energy sources, the energy structures for particular EU states are quite diverse (fig. 2). The spatial analysis of renewable energy sources in 2014 in selected EU states demonstrated that the dominant position in the structure was taken by the energy obtained from solid biomass (43.8%), with rural areas being the richest in it. Energy-providing biomass may be derived from annual agricultural products, residue and waste material from agricultural production, and perennial energy crops (Jezierska-Thole et al., 2016). The second most widely used energy was obtained from water (16.5%), and the third kind was derived from the wind (11.1%). The other sources were not so conspicuous, namely: biogas (7.6%), liquid biofuel (7.1%), solar energy (6.1%) and renewable household waste (4.6%). At the bottom of the ranking there was geothermal energy (3.2%) (Challenges…, 2013).



Source: own elaboration based on data: Eurostat; GUS (Energy…, 2016)

Figure 2. Structure of renewable energy sources in total renewable energy generation in Poland and EU-28 (2014; in %)

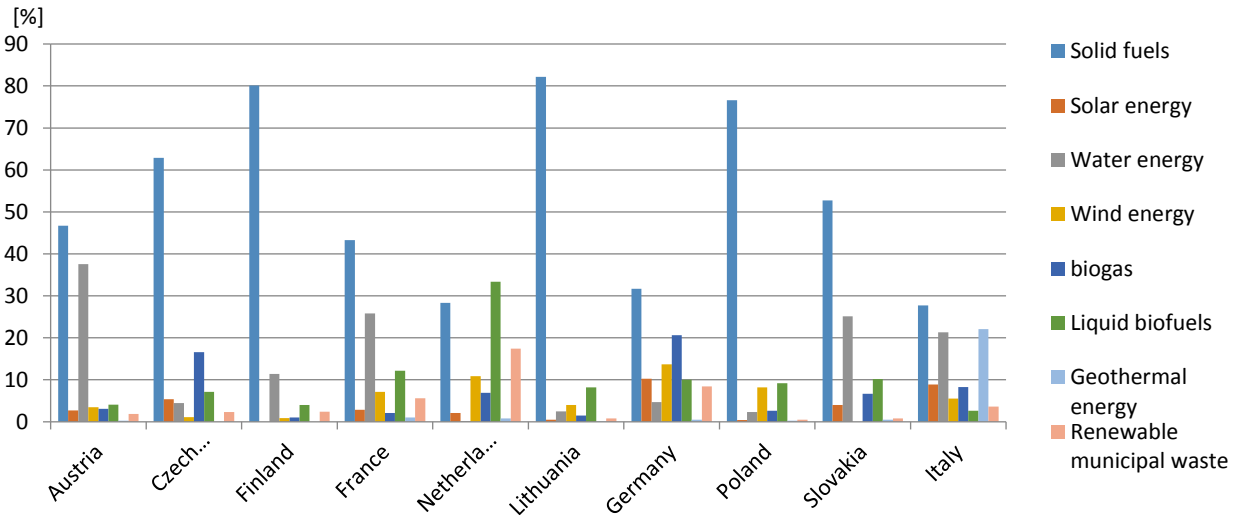
In the period of 2011-2014 the highest growth dynamics characterised solar energy (+2.4%), followed by wind energy (+1.7%) and biogas (+1.2%). The most notable improvement in the role of solar energy was discovered in Italy and Germany, France and the Netherlands. As far as wind energy is concerned, an increase in its share was established for, e.g.: Austria and France, but it was the highest in Poland (+4.5%). However, due to the implementation of the so-called 'distance act', which raised the limit for the minimal distance of wind turbines from residential buildings, the development of this form of energy was substantially curbed (The law…, 2016; Renewable…, 2015). With regard to biogas, a rise was recorded in the Czech Republic, Germany and Italy.

A fall in the renewable energy exploitation affected the sector of solid biofuels (-5.5%) and a negligible decrease was suffered by the sector of renewable household waste (-0.4%) and geothermal energy (-0.3%). The most dramatic decline in the share of biofuels was in Poland, the Netherlands, France and Austria. The situation is related, among other

things, to economic crisis and public debt which made many EU states (including leaders in this particular industry branch) face reductions in the support for renewable energy and a slowdown of the pace of its development. Simultaneously, a discussion was raised in the European Union on the production costs of electrical power from renewable energy sources (Nunes et al., 2017). The largest part in the structure of renewable energy was taken by biomass in Lithuania (82.2%), Finland (80.1%) and Poland (76.6%; down from as much as 85.2% in 2011; fig. 3). Basically, observable is a slow but sure decline in the role of biomass, which is to the benefit of, mostly, wind and solar energy.

The energy obtained from the wind is by far the most important in Germany (13.7%) and the Netherlands (10.9%). In Poland, the ratios for this kind of energy (8.8%) are below the EU average (11.1%), as is the case in Lithuania (4%). Solar energy (EU average 6.1%) is intensively used in Germany (10.3%) and Italy (8.9%), and then in the Czech Republic (5.4%) and Slovakia (4%). In Poland and Lithuania the share of solar energy in the renewable energy production is negligible, with 0.4% and 0.5%, respectively. In some countries water energy is of great importance. It is at the forefront of renewable energy production in Austria (37.6%), and then in France (25.8%), Slovakia (25.1%) and Italy (21.3%).

On the other hand, Germany excels at biogas energy production. Its share (20.6%) is three times as high as the EU average (7.6%). In Poland and Lithuania the use of biogas in the renewable energy production is unremarkable, with 2.6% and 1.5%, respectively. With regard to the use of liquid fuel, leadership belongs to the Netherlands (33.4%), as is the case with the use of household waste (17.4%). Geothermal energy is of no significant importance and the only country where its role is conspicuous in the renewable energy structure is Italy (22.1%). The above analysis demonstrated that the use of renewable energy sources is not always strongly related to natural conditions determined by the geographical location and natural features of the climate. In some countries it can be observed that the development of renewable energy is linked with the economic structure and the raw materials produced, e.g. these of agricultural origin (biogas, biomass).



Source: own elaboration based on data: Energy…, 2016

Figure 3. Structure of obtaining renewable energy (by source) in selected EU countries (2014, in %)

One of the aims of the European Union in the field of renewable energy development is to increase the share of electrical power derived from renewable sources in the final gross energy consumption. In 2014 the share was measured at 27.5% and since 2011 it grew by 5.8%. The percentage was highly diversified in individual countries and oscillated from 10% in the Netherlands to 70% in Austria. In Poland the share increased by +4.2% to 12.4% (2014), while in Lithuania it rose by 4.7% to 13.7% (2014). The structure of RES in electrical power production demonstrated a growth in the solar energy (+3.9%) and wind energy (+1.7%) sectors. On the decline are solid biofuels (-1.2%) and hydropower (-4.4%).

CONCLUSIONS

The role of renewable energy sources in the European Union states is gradually gaining momentum and these sources are becoming one of the key components in energy production. This situation is mostly affected by ecological arguments, energy security considerations, as well as the Energy and Climate Package accepted in March 2008. It is observed that the amount of energy derived from renewable sources is constantly rising, with the simultaneous decrease in the total production of primary energy. It translates into the systematic growth in the share of RES in the total primary energy production. Noticeably, the structure of energy sources presents a substantial share of biomass, whose role is on a slow but steady decrease. What is on the increase is the energy derived from the sun, wind and water.

The analysis proved that the highest share of renewable energy in energy balances featured predominantly in Scandinavian countries (Sweden, Finland, Denmark), Baltic countries (Latvia, Estonia, Lithuania) and in some other countries in Central Europe (Austria, Romania, Croatia). Poland also sees a strengthened position of RES, however, the changes are not so much apace here. In 2015, the share of RES was at 11.8%, with the target set for 2020 being at the level of 15.0%. The data showcase that the projected aim is likely to be achieved; however, the few years to come should

envisage some intensification of activities oriented to this goal. Biomass now enjoys the dominant role but its significance is gradually waning, which favours wind energy and biofuels.

The development of the renewable energy sector may substantially contribute to the development of rural areas. It is related to diversification of incomes from agricultural activities by creation of new work places and diversification of directions of agricultural production, thus yielding structural changes in agriculture. Secondly, owing to its eco-innovative nature, it triggers positive changes in agricultural environment, including the natural environment, paving the way for the sustainable development.

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