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# POWER PLANTS OF POLAND AND SLOVAKIA IN ASPECT OF SUSTAINABLE DEVELOPMENT

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**Abstract**: The main aim of this paper was to determine the efficiency and appropriateness of the support schemes used for the support of renewable energy sources in Poland and Slovakia. The results showed that the suitability of using a particular instrument depends on the conditions in the country. Based on the results, the most appropriate instrument within Poland is a factor that brings together the level of energy consumer taxation and tradeable certificates. Grants were also a suitable instrument in this country, while subsidies did not have a significant effect. In the case of Slovakia, the only significant (appropriate) instrument was the factor capturing the level of electricity taxation and the level of tariffs provided to market operators.

**Key words:** support mechanisms of renewable sources, renewable sources, grants, subsidies, feed-in tariffs, tradeable certificates

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## Introduction

Not only in recent times has there been increasing pressure on authorities in the areas of environmental protection and reducing the impact of economic activity on climate change. Energy is one of the key inputs in the production process, so this area is one of the main concerns of the public and government in mitigating greenhouse gases. In addition, the energy sector (or relatively low energy prices) is one of the key aspects of competitiveness. Therefore, the instrument taken must be sufficiently vigorous, while not jeopardizing the economic growth of the country. One way to do this is to use renewable energy sources, which cause several effects simultaneously. Their application significantly reduces the country's energy dependence and at the same time aids price stability (absence of fluctuations due to the level of fossil fuel extraction). If a country has a relatively high share of renewable energy production, this may also have the effect of lowering prices (due to low operating costs of power plants from renewable sources). Last but not least, this helps to significantly reduce the volume of greenhouse gas emissions. The main problem in this area is therefore only the relatively high cost of constructing power plants of such resources, which also significantly reduces the return on

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investment. Therefore, an important step is to set incentives to create a disturbance and distortions in the energy market, that sends the preference for building a renewable energy source signals to market operators. In this paper we will be interested in these tools and their use in the two V4 countries, Poland and Slovakia.

## Framework

The first important step is to determine the current situation in both countries observed, so we will focus on the structure of electricity sources in both countries. Figure 1 (below) shows the proportion of the development of electricity production from fossil fuels and renewable sources within Poland. It also shows the internal structure by type of fuel.

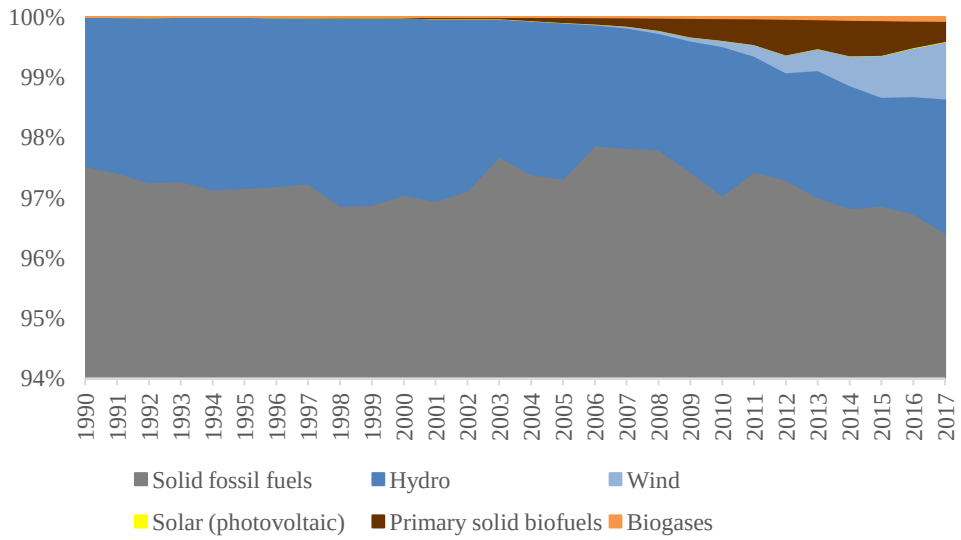


**Figure 1 Gross electricity production in Poland by type of fuel** (based on Eurostat data)

Poland, as the second largest consumer of fossil fuel energy in the EU, has a relatively small share of electricity production from fuels defined as renewable sources. While such a situation presents great potential for improvement, it also represents an unflattering assessment for the country. We also consider one of the reasons for the status, that there is no completed nuclear power plant in Poland (only one unfinished and abandoned construction of it) and it's still a very sensitive topic even in the discussions in this country. At the same time, the country doesn't make use of all the possibilities offered by its location (e.g. tide and wave power plants). In addition, this development reflects developments in overall energy use during the first half of the observed period, ranging from 2.47% in 1990 to 14.43% in 2017. The graph shows that o proportional expression of fuel structure. Since the graph contains proportional expression of the fuel type structure, this should be

considered. So, we have to consider a slight decrease in the share of fossil fuels together with the growth of the country's energy demands as the aggregate production increases.
Subsequently, we will focus on the development of the issue in the second country, which is Slovakia. Figure 2 shows the percentage of each fuel type in electricity production.

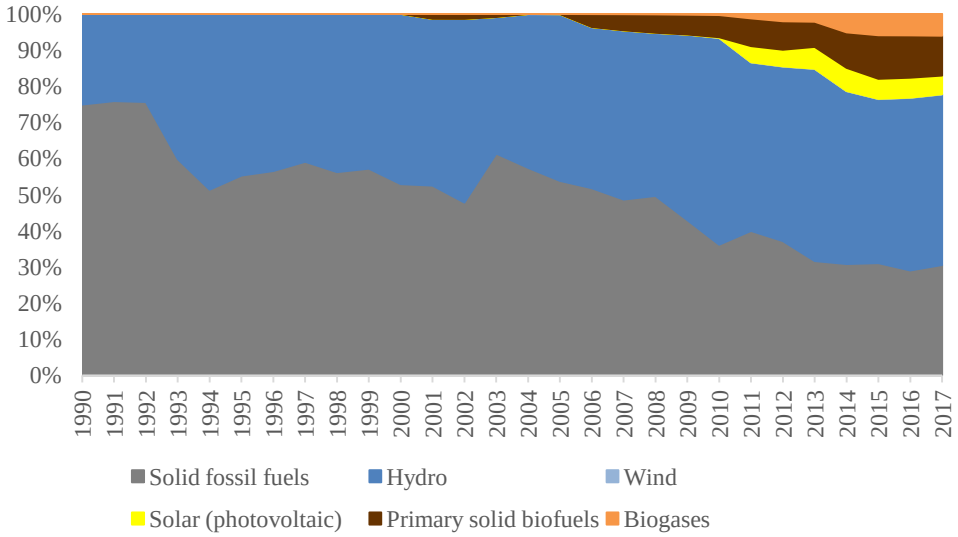


**Figure 2 Gross electricity production in Slovakia by type of fuel** (based on Eurostat data)

At first glance it might seem that the development of the situation in Slovakia is diametrically better than in Poland. However, the state of affairs only records developments within the production of electricity. If we consider the overall energy mix, the development is significantly different (and the development in the country is not adequate). This difference results from the generation of energy from two nuclear power plants (Mochovce and Jaslovské Bohunice) and at the same time with a relatively large system of hydroelectric power plants in the Váh basin, respectively waterworks (Gabčíkovo, Liptovská Mara, Domaša, etc.) If we were also considering other uses of energy (e.g. for thermal purposes / thermal power plants), the value for this Central European country would be much worse, since within other energy sectors fuel is a mix consisting of renewables at a significantly lower level (mainly in terms of heat production). This situation affected the overall share of low-carbon resources across all energy sectors ranging from 9.63% in 1990 to 24.76% in 2017.
The next step is to identify and characterize support mechanisms. Based on Meyer (2003), we consider several instruments, including direct subsidies (or capital

transfers), feed-in tariff, quotas for renewable sources and tender for renewable sources. However, due to the lack of observations of the last two instruments for the compared countries (some data weren't available), we will not consider them further.

In contrast to the Feed-in tariff policy, which is price-based (fixed-price and premium-price), the other instrument Renewable portfolio standards policy is quantity-based. However, this policy is appropriate when a market view policy is applied by the government. Although Europe has attempted to organize a single harmonized tariff system, it is believed to be impossible due to the vast differences in policies across the member countries. The RPS system has not been developed in Europe (as whole), as most European countries have previously instituted the tariff system (Abolhosseini and Heshmati, 2014).

Investment Grants are supported by governmental (and European) institutions to invest in renewable energy projects in the form of non-reimbursable payments for the construction phase of the project (Kitzing et al., 2012). Moreover, according to the authors, this form of support is used as a supplementary support scheme.

Unlike grants, subsidies are redistributed on the basis of predetermined criteria. If some subject complies them, subject can apply for finance (e.g. for a certain amount of energy supplied to a grid from renewable energy sources). In addition, Nicolini and Tavoni (2017) have identified that the instrument is effective within the European Area countries. However, according to the results presented by them, this impact is inelastic.

In addition, tax exemption should be considered as a fiscal instrument. The following table 1 summarizes the tools used in Poland and Slovakia.

**Table 1 Support schemes in Poland and Slovakia** (Sawin et al., 2010)

| | **Feed-in tariff** | **Renewable portfolio standard/quota** | **Subsidies, grants, rebates** | **Investment** | **Tax or VAT reduction** | **Tradable RE certificates** |
|---|---|---|---|---|---|---|
| *Poland* | | X | X | | X | X |
| *Slovakia* | X | | ● | X | X | |

● - although it was not listed within the source, the tool is used (but only marginally)

The use of these instruments should also have an impact on the increase in final energy prices, but, according to Bode (2006), mechanisms aimed at promoting renewable energy sources may have an additional spill-over effect in addition to cost increases for consumers, leading to lower energy market prices, which results from lower marginal costs for renewable energy production (and it pushes out those higher cost power plants).

However, it is also important to consider the appropriateness of using the instrument and the effect it will bring on the economy. We have made this statement based on Fagiani et al. (2013), according to which feed-in tariffs dependent on the regulator's decision and could result in either low efficiency or

over-investment. Lewis and Wiser (2007), on the other hand, argue that stable feed-in tariffs are proving to be one of the most effective tools to guarantee the stability and attractiveness of a given electricity market for local manufacturing, while adding that different types of tools can be effective if implemented carefully and appropriately adapted to market conditions.
In addition, it is necessary to consider another effect associated with renewable energy sources. Due to the fact that most of these sources are exempt from dependence on fuel source (with the exception of biomass and biogas), and are largely fixed to variable costs, they are largely immune from market volatilities, especially when compared to conventional sources of natural gas generation (Couture and Gagon, 2010).

## Methodology

The main aim of the paper is to determine the current status in the Polish and Slovak energy situation perceived as a component of the concept of sustainability. In determining this, we will be particularly interested in the development of renewable energy sources and the impact of the policy instruments used in the two economies observed. Our primary interest in the political aspect stems largely from the fact, that it is government intervention that distorts the market largely contributing to increasing the share of renewable energy sources. We consider partial objectives to determine the impact of energy subsidies on the development of the share of low-carbon resources. In addition, we were interested in the impact of capital transfers (grants) on the development of a given indicator of sustainability of electricity generation, which we consider as another sub-target. In addition, we were also interested in distorting the market into a political order (i.e. within a positive connotation) through the rate of taxation and the setting of tariffs for the purchase of energy from specific renewable energy sources.
Based on the objectives described above and previous contributions to this issue, we have drawn up the following hypotheses:

- H1: Increasing the level of funds allocated by the relevant central government for subsidies to the energy sector contributes to increasing the relative expression of the use of renewable resources.
- H2: Increasing the level of funds allocated by the relevant central government for capital transfers (grants) to the energy sector contributes to increasing the relative expression of the use of renewable resources.
- H3: The increase in the level of taxation and the increase in the level of electricity purchase tariffs from low-carbon sources (determined by the difference in the level of the final consumer price of electricity before and after taxes or tariffs)

To determine the above-mentioned impacts, we have established a GLS model whose transcription looks like this:

$$RES_t = f(PES_t, EP_t, Sub_t, CT_i, Tax_t)$$

where *RES* represents the proportion of the use of renewable energy sources, we perceive *PES* as the level of primary energy consumption per capita (which we understand as the 1st control variable), *EP* captures the level of final consumer price of electricity for households (2nd control variable), *Sub* is the amount of government subsidies to the per capita electricity generation sector, we consider *CT* as the level of capital transfers (mainly grants) to the energy sector expressed as per capita and *Tax* represents the average level of taxes and price increases caused by tariffs, tradeable certificates and levies paid per capita within economy.
To calculate the results was used the program R (v3.4.3), its extension RStudio (v1.1.442) exactly.

## Results

Based on the above functional relations expressed by equations, we have created the model presented in Table 2. The EP variable was thrown out of the model due to multicollinearity problems.

**Table 2 Results of RES prediction model for Poland**

| | coefficient | std. error | t | p-value |
|---|---|---|---|---|
| *(intercept)* | 0.4454 | 0.1708 | 2.6070 | 0.0350 ** |
| *PES* | -15.6366 | 6.3005 | -2.4820 | 0.0421 ** |
| *Sub* | -0.0067 | 0.0038 | -1.7900 | 0.1167 |
| *Grants* | 0.0035 | 0.0009 | 4.0460 | 0.0049 *** |
| *Tax* | 0.0509 | 0.0104 | 4.8700 | 0.0018 *** |
| $R^2$ | 0.9282 | AIC | -64.8262 | |
| Adj. $R^2$ | 0.8872 | BIC | -62.4017 | |

The results showed that the changes in primary energy consumption had a significant inversely proportional impact on the proportion of renewables within Poland. If this indicator increases by 1% under otherwise unchanged conditions (ceteris paribus), we expect a sharper decrease in the share of energy generated by the low-carbon method, down to 4.66%. This clearly implies that such electricity production is significantly elastic but negative. At first glance it might seem that in the short term the economy is not capable of major changes in the structure of energy sources, but due to the nature of data (annual) during which it is possible to change the structure (construction less than one year, especially in case of solar and wind power plants). It follows from the above that the pressure of the state administration authorities was not strong enough during the observed period and did not contribute to the required change. Moreover, this situation is even worse in the light of more significant improvements in Poland's energy intensity.
An interesting finding is that, the volume of funds allocated to various forms of subsidies for renewable energy sources did not bring the expected effect in the form of an increase in the utilization rate of this energy source. From these findings we can conclude that the level of subsidies in Poland was not sufficiently high or

was not sufficiently attractive due to the amount of support, or due to the high bureaucracy involved in obtaining it. And these reasons led to the absence of statistical significance of this predictor.

In the case of grants (or capital transfers) the situation is different, which follows from their characteristics, as in the case of subsidies we considered a non-repayable expenditure on construction, while in this case we consider funds intended to reduce production (operating) costs for companies in industry. According to the model, grants have a positive impact on the change in the share of renewable energy sources in Poland. With a 1% increase in funding allocated to grants, we expect a 0.17% increase in the share of renewable energies. Thus, the impact of grants is inelastic. It is precisely reducing the costs of operators creating a distortion of the market, where producers (but only the ones, who receive the grant) receive bad signals (from a market perspective) and prefer to build low-carbon power plants.

The last predictor in the GLS model is the electricity taxation rate. However, in addition to the amount of taxes, the impact of tradeable certificates for renewable energy sources (tariffs are not used within Poland) or different levies was also included here. Due to the fact that the factor was constructed on the basis of the difference between the taxed (considering all 3 types) and the non-taxed end-price (consumer price, where consumer is considered as households) of energy, it was not possible to separate the impacts of the above mentioned instruments and had to be considered together. The results showed that these instruments have a significant and positive impact (as well as grants), but in this case the effect is slightly above unit elasticity (i.e. elastic). This was determined on the basis that a 1.11% increase in the share of renewable energy sources is expected with a 1% change in taxes, certificates and levies. As this is a long-term support (in the form of an increase in profits to the detriment of others within the market), which, unlike grants, affects all market players (with the same characteristics) equally.

A similar model was developed for Slovakia, the results of which are shown in Table 3 below. Compared to the original model, we did not consider the predictors dealing with the EP consumer price of energy due to the presence of the multicolinearity problems described above and the amount of capital transfers due to the low variability of the variable, resp. very low values (both in overall terms and per capita adjusted data).

**Table 3 Results of RES prediction model for Slovakia**

| | **coefficient** | **std. error** | **t** | **p-value** |
|---|---|---|---|---|
| *(intercept)* | 0.4454 | 0.1708 | 2.6070 | 0.0350 ** |
| *PES* | -15.6366 | 6.3005 | -2.4820 | 0.0421 ** |
| *Sub* | -0.0067 | 0.0038 | -1.7900 | 0.1167 |
| *Tax* | 0.0509 | 0.0104 | 4.8700 | 0.0018 *** |
| $R^2$ | 0.9282 | AIC | -64.8262 | |
| Adj. $R^2$ | 0.8872 | BIC | -62.4017 | |

Slovakia has also confirmed the presence of a significant negative impact of primary energy consumption on the percentage of renewable energy sources usage. However, there is less difference between the two compared countries. When we considered a 1% increase in energy consumption (per capita) while respecting the ceteris paribus condition, the development of the RES indicator decreased by 1.80%. Again, this is a negative elasticity, but the deterioration effect in Slovakia is of the order of magnitude lower. Given the above-mentioned premise regarding the length of construction of some types of power plants, the tools taken by the governments of the Slovak Republic during the period under review were not sufficiently robust (and sustainable), but still at a higher level than the Polish ones.
In Slovakia, too, the impact of subsidies proved to be statistically insignificant. This situation arises from the characteristics of subsidies - they are intended for a specific entity for the construction of a power plant, but also from the method of their allocation. In this case, we are referring to the approval of permits to companies, which (in particular solar power plants) build the power plant, although they do not connect it to the grid. Moreover, this is not an isolated case for this country, but rather a failure of responsible structures and authorities. And such negative aspects may subsequently affect the willingness to allocate funds to this agenda and this is leading to a reducing the effect.
The last considered predictor also deals with the rate of taxation, tariffs and levies. As with the model on data from Poland, the existence of a statistically significant and directly proportional impact has been demonstrated. Considering otherwise unchanged conditions (ceteris paribus), with a 1% increase in the level of taxation, tariffs and levies (or factors significantly affecting the final consumer price of energy), the share of resources obtained through low-carbon methods increased to 0.2%. It follows that taxes and tariffs are inelastic. Such a lower level of impact (compared to Poland) suggests that the policy instrument used to increase the share of renewable energy sources has been (and is) used to in a greater extent (e.g. by amending the Renewable Energy Promotion Act, which made condition of the purchase of energy from such sources for distribution companies at level set by tariffs). And the frequent use of this tool could have contributed to reducing the effect, or eventually, the phenomenon that occurred 4 years after the above-mentioned amendment as a response from distribution companies - by not accepting requests to connect sources over 10 kW to the grid, officially for concerns about network stability and security of supply.

## Discussion and conclusion

Also, in the discussion, we will address both countries separately, although there are similar characteristics between them in this field. In the case of Poland, it appears that although the low-carbon power generation ratio has increased by 10% over the period under review, it can be argued that this increase was largely supported by a reduction in electricity use (see PES indicator evolving), which is of course one of the sustainability objectives in the area, but achieving this goal

distorts the results in terms of the share of renewable energy sources. Thus, this increase in the share of low-carbon resources was largely due to fluctuations in primary energy consumption around the 0.03 toe per capita (with constantly increasing of country's production), and the ongoing climate change also played a role, where the average temperature increased, reflecting the decrease in heating degree days in Poland. Based on these facts, we identify the efforts of the central government as insufficient.

Based on the findings, the most appropriate factor (out of 3 evaluated) influencing the development in the field of use of renewable energy sources is the level of tradeable certificates for the renewable energy sources, whose use in Poland has not yet reached the optimal value). Such an impact on the equilibrium of the electricity market will have a significantly better impact than the other instruments examined (capital transfers and subsidies), which only affect selected entities and do not achieve the desired effect in synergy with the bureaucracy associated with them. (while in the case of certificates and the resulting higher tax, the opposite is true). This confirms the findings of Jacobsson et al. (2009), which claims that the prospect of rents is necessary and appropriate incentive for encouraging entrepreneurship in the market economy, although rents should be channelled to risk taking innovators / entrepreneurs and should not be confused with excess profits captured by incumbents free Riding on badly designed regulations. The funds thus obtained could subsequently be used to treat existing heating plants (which also produce electricity), thus reducing the level of pollution. Some might assume that reducing the amount of money allocated to the construction of renewable energy sources will reduce their share, but if the certificates are set appropriately, this undesirable effect would not occur (since operators would be encouraged to build renewable sources that generate higher profits) ) and available funds could be used to reduce the pollutants produced by existing fossil fuels, or in the long term to build water works (costly for most market players). The same findings have been determined by Linares at al. (2008), where they believe that both instruments may be used in order to achieve the same objective: support for renewable energies contributes to a reduction in carbon emissions, by increasing the relative share of renewables in the energy production mix (although this effect may be reversed in dynamic terms under certain conditions). However, it should be added that, as part of the findings, we do not propose the complete elimination of both instruments (subsidies and grants), only lowering their level to the optimal level (adherence to the value for money principle) so that surpluses can be allocated elsewhere and more appropriately.

In Slovakia, too, there was a lack of government support for the use of renewable energy sources, based on similar rules as in the case of Poland. However, the analysis of the instruments revealed a different situation. While in the case of Poland, taxing and setting tariffs for the purchase of energy from renewable sources is the most appropriate alternative to improving sustainability in terms of electricity generation, in the case of Slovakia this tool is much less effective. This

situation is related to the excessive use of this instrument and to the defence position of market players (distribution companies). We therefore consider that in the case of Slovakia, it would be preferable not to raise (or slightly increase) the level of tariffs in order to achieve the optimum of this instrument. By contrast, capital transfers are absent (or relatively low) in Slovakia. On the basis of the above, we do not consider the instrument to be the most appropriate in terms of its directness (and not the impact on the whole market); In the absence of this instrument (or other), the government is losing one of the options for influencing sustainability in this area. We therefore recommend slightly increasing the amount of subsidies and grants under this small open economy. This corresponds to the findings of Toke (2008) on the possibility of undermining existing nationally based support systems (e.g. tariffs). Our findings are also confirmed by the opinion of Menanteau et al. (2003), who argue that in practical terms both taxes and renewable premiums need not be equivalent without loss of generality.

Based on an analysis of two countries (whose situation is similar in terms of sustainability of electricity generation), we conclude that similarity does not guarantee the versatility of the instruments used and we must look at each country of the European 28 individually through its specificities, this will help desirable developments in the use of renewable electricity. This suggests that the different approaches proposed by other authors (often contradictory) are correct, just as to whether they will be applied in an economy that has the right conditions to apply them. One aspect of the choice of suitable schemes has also been addressed, among others, by Boomsma et al. (2012).

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## ELEKTROWNIE W POLSCE I SŁOWACJI W ASPEKCIE ZRÓWNOWAŻONEGO ROZWOJU

**Streszczenie:** Głównym celem tego artykułu było określenie wydajności i odpowiedniości systemów wsparcia wykorzystywanych do wspierania odnawialnych źródeł energii w Polsce i na Słowacji. Wyniki pokazały, że przydatność korzystania z określonego instrumentu zależy od warunków panujących w kraju. Na podstawie uzyskanych wyników najodpowiedniejszym instrumentem w Polsce jest czynnik, który łączy poziom opodatkowania konsumentów energii i zbywalnych certyfikatów. Dotacje były również odpowiednim instrumentem w tym kraju, a dotacje nie miały znaczącego wpływu. W przypadku Słowacji jedynym istotnym (odpowiednim) instrumentem był czynnik odzwierciedlający poziom opodatkowania energii elektrycznej i poziom taryf przekazywanych operatorom rynku.

**Słowa kluczowe:** mechanizmy wsparcia odnawialnych źródeł, odnawialne źródła, granty, dotacje, taryfy gwarantowane, zbywalne certyfikaty

## 波兰和斯洛伐克的电厂可持续发展

**摘要**:本文的主要目的是确定用于支持波兰和斯洛伐克可再生能源的支持方案的效率和适当性。结果表明，使用特定工具的适用性取决于该国的条件。根据结果，波兰最合适的工具是将能源消费税和可交易证书的水平结合在一起的一个因素。赠款在该国也是一种合适的手段，而补贴并未产生重大影响。就斯洛伐克而言，唯一重要的（适当的）工具是捕获电税水平和向市场运营商提供的电价水平的因素

**关键词**:可再生资源支持机制，可再生资源，赠款，补贴，上网电价，可交易证书