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ECONOMICAL ANALYSIS OF FINANCIAL SUPPORTS FOR LARGE-SCALE PHOTOVOLTAIC PV PLANTS IN EASTERN EUROPEAN UNION COUNTRIES

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Abstract: ***Today, photovoltaic (PV) attracts considerable interest among renewable energy sources (RES), because of its potential to significantly contribute to the future of clean energies. However, PV development is strongly related to the support policies introduced by national governments. The modification or fading out of such support schemes can strongly influence the development of the PV market in any given country. Although the PV market in European developing countries is still quite small, it has been growing rapidly in recent years. Until 2006, the installation of small off-grid PV plants prevailed in eastern EU countries. Starting from 2008, large-scale on-grid PV plants have been put into effect. Today on-grid installations constitute more than 95% of the total installed PV plants. The large increase of PV market in the last two years is a consequence of the enormous development of PV sector in the Czech market, stimulated by effective support mechanisms. Other developing member states, such as Slovakia and Bulgaria, have adequate PV support schemes including, in particular, effective Feed-in Tariff (FIT) systems. Other support mechanisms are tradable green certificates (TGCs), capital subsidies, tax credit and net metering. In this paper, after a brief review of national support policies in PV technology in the considered EU developing countries, the authors perform an economic analysis of the main support mechanisms that are implemented in these countries. The comparative analysis is based on the calculation of the cash flow, the Net Present Value (NPV) and the Internal Rate of Return (IRR) indices. The analysis shows that in some situations, support policies can be inconvenient for the owner of the PV system and that, in many cases, the differences between the implementation of the same support policy in different countries, can give rise to significantly different results. The comparative analysis carried out in this work could help: to evaluate the impact of the PV energy measures in eastern EU member states; to gain an insight into green energy companies by identifying potential PV markets and investigating the policy landscape across eastern EU countries.***

Keywords: ***Large scale PV systems, feed-in-tariffs, tradable green certificates, net metering, economic analysis***

1. INTRODUCTION

Among various renewable energy technologies, PV today attracts growing attention due to its potential to contribute a major share of green energy in the future.

The solar resource worldwide is abundant and cannot be monopolized by any country. Moreover, PV and other RES are the only sources of energy that will offer a price reduction rather than an increase, in coming decades.
The most important advantages of the PV energy are:

- it is an unlimited source of energy and it can be exploited all over the world;
- it can be easily integrated in private or public buildings without environmental impacts typical of other RES technology;
- due to the absence of moving parts, the maintenance and management costs are very low.

2009 has seen the most important annual capacity increase ever, which is particularly impressive in light of the difficult financial and economical circumstances prevailing during the year. The global PV market counted an additional increase in installed PV capacity of about 7.2 GW in 2009, reaching a total capacity of over 22 GW world-wide. In 2010, global cumulative installed PV capacity is expected to increase by at least 40%, while the annual growth is expected to increase by more than 15% [1].
During 2009, Germany remained at the first place, with Italy, Japan and the U.S. markets to follow.
Although the PV market in European developing countries is still quite small, it has been growing rapidly in recent years. Until 2006, the installation of small off-grid PV plants prevailed in eastern EU countries. Starting from 2008, large-scale on-grid PV plants have been put into effect. Today on-grid installations constitute more than 95% of the total installed PV plants.
The large increase of PV market in the last two years is a consequence of the strong development of PV sector in the Czech Republic, stimulated by effective support mechanisms. In 2009 Czech Republic shows an important growth with 411 MW of installed PV plants. Also Slovenia and Bulgaria have adequate PV support schemes including, in particular, an effective FIT system.
The cumulative installed PV power, in 2008, in each eastern EU member state is represented in table 1.
Unfortunately, the development of PV sector is strongly related to the political support measures carried out in the different countries. In effect, the cost of PV energy is still rather high and several studies are being carried out to research new PV materials and devices, focusing on the reduction of PV generation costs. Moreover, the

development of the PV sector is obstructed by several factors, such as:

- lack of effective national support policies;
- strong nuclear and oil lobbies;
- high grid connection costs paid by PV-owners;
- complexity of grid connection procedures.

Table 1: Cumulative installed PV power in 2008 in eastern EU countries

Country	Off grid [kW]	On grid [kW]	Total [kW]
Bulgaria	32	1375	1407
Czech Republic	380	54294	51674
Estonia	12	0	12
Hungary	180	270	450
Latvia	4	0	5
Lithuania	55	0	55
Poland	832	179	1011
Romania	205	245	450
Slovak Republic	20	46	66
Slovenia	100	2046	2146
Tot	**1820**	**58455**	**57275**

In the last years, different instruments to finance RES have been defined and put into effect.
FITs and TGCs are the most popular support mechanisms for the RES development all over the world.
Other support measures are capital subsidies, tax credit and net metering, usually used as supplementary support schemes.
A detailed description of this support policies can be found in [2], [3] and [4].
In this paper, after a brief review of national support policies carried out by different EU developing countries in PV technology, the authors perform an economic analysis of the main support mechanisms that are implemented in the same countries.
The cash flow, the NPV and the IRR indices are used to carry out the economical comparison.
The analysis is focused on large-scale PV plants. An economical comparison of small and medium-scale PV plants in EU member states is reported in [5] and [6].
The analysis shows that, under defined conditions, support policies can be inconvenient for the PV-owner and the differences between the implementation of the same support policy in different countries, can give rise to significantly different results.

2. SUPPORTING STRATEGIES FOR PV SYSTEMS IN EASTERN EU COUNTRIES

This section examines the current support policies for PV systems as implemented in eastern EU member states.
For each considered country, a brief description of political landscape in PV sector is reported. The attention is focused on support measures for large-scale PV plants.
Table 2 shows the current financing strategies for PV technology in eastern EU member states.

In the next sections, all reported prices are always VAT excluded and are expressed in euro (exact level of FIT depends on exchange rate).

Table 2: Current financing strategies for PV systems in eastern EU countries

Country	FIT	TGC	Capital subsidies	Tax credit	Net metering
Bulgaria	x				
Czech Republic	x		x	x	
Estonia	x		x	x	
Hungary	x		x		x
Latvia	x				
Lithuania			x		
Poland		x		x	
Romania		x	x	x	x
Slovak Republic	x		x	x	
Slovenia	x		x		

2.1 Bulgaria

In Bulgaria, a new FIT system has been introduced and became effective in April 2009 [7].
The FIT values are detailed in Table 3.

TABLE 3: Mandatory purchase prices in 2009 for electricity generated from PV systems in Bulgaria

	≤ 5 kW (€/kWh)	> 5 kW (€/kWh)
Mandatory purchase prices	0.421	0.386
Other informations	Duration: 25 years	
	Valid until the end of 2015	

FITs are granted over a 25 year period and are adjusted each year to electricity prices.
As it is shown in table 3, the FIT's value for medium and large-scale PV plants is around 10% lower than the small-scale ones.

2.2 Czech Republic

The Czech Republic grew very rapidly in the last years due to the implementation of a well-designed FIT system.
The convenience of the implemented FIT system has urged many operators to invest in large ground-based PV plants.
The Act on Promotion of Use of Renewable Sources [8] allows producers to choose between a FIT or a feed-in premium. FITs are recognized over a 20 year period, whilst the green premium is paid on top of the market price. The annual FIT and feed-in premium are updated each year.
FIT and premium values, valid after January 2009, are outlined in Table 4.
Additional supports applied to PV systems in the Czech Republic are tax incentives, investment subsidies and low-interest loans.

TABLE 4: FIT and green premium in 2009 for electricity generated from PV systems in the Czech Republic

		Fixed FIT (€/kWh)	Green bonus (€/kWh)
FIT	< 30 kW	0.4987	0.461
Green premium	> 30 kW	0.4950	0.457

2.3 Estonia

The utilization of PV energy in Estonia has increased very slowly until now, because the FITs were too low.
In Estonia, FITs are regulated by article 57-59 of the Electricity Market Act [9].
The Act has introduced a single FIT level for all RES technologies. Accordingly, the electricity generated by a RES-energy producer can be purchased at a price of 0.074 €/kWh. In addition, the RES owner has the possibility to sell the electricity it has produced at a current price equal to 0.054 €/kWh. The support period has been extended to 12 years from the start of production.
FIT values for electricity generated from RES in Estonia are reported in Table 5.

TABLE 5: FIT values in 2009 for electricity generated from RES (PV included) in Estonia

RES Technology	**Purchase obligation (FIT)**	**Support provided by the TSO** (starting from 1 January 2010)
	(€/kWh)	(€/kWh)
All RES	0.074	0.054

Additional supports applied to PV systems in Estonia are tax incentives and investment subsidies.

2.4 Hungary

The PV Hungarian market has grown slowly in recent years, due to the low FIT values.
The new FITs have been introduced with a new Electricity Act [10]. Accordingly, FITs are granted for RES installations smaller than 20 MW for the lifetime of the RES plant. The FIT value for PV and wind energy, valid as from 1st January, 2009, is equal to 0.105 €/kWh. Moreover, the electricity produced by PV plants is eligible for the net metering system. Additional support measures are subsidies and soft loans.

2.5 Latvia

Until now, the use of solar electricity in Latvia has been very low, because of the climatic conditions and the low FITs values.
RES producers have the right to sell the electricity generated by their plants at a guaranteed price, depending on the type of RES. For 2009, the FIT value for PV energy is 0.423 €/kWh, applies to the whole life of the system [11].

2.6 Lithuania

Also in Lithuania the use of PV energy is growing very slowly, due to the northern latitude and the low applied RES-support mechanisms.
The only promotion mechanism for PV in Lithuania are investment subsidies. The maximum subsidy is approximately 200000 €, granted over a three-year period and must not exceed 70% of the total investment [12].

2.7 Poland

The development of PV energy in Poland is growing very slowly because of the following factors:

- lack of an effective support system;
- negative approach of the Polish government.

The current tariffs are too low for most investors and as a result, the development of PV sector is slow.
For the promotion of RES electricity, a quota system with TGC is active in Polonia. Transmissions and distribution companies are obliged to purchase a minimum percentage of green energy from RES producers. The obligation can be met through the acquisition and redemption of certificates of origin that certify that the electricity has been produced from RES or paying the replacement fee. The percentage rates, independent of the used technology, are outlined in table 6 [13].

TABLE 6: Percentage amount of the purchase obligation per year, until 2017, in Poland

	Purchase obligation per year (%)						
All RES	**2008**	**2009**	**2010÷ 2012**	**2013**	**2014**	**2015**	**2016**
	7	8.7	10.4	10.9	11.4	11.9	12.4

The total income a RES producer can achieve in 2009 is about 98.37 €/MWh, which is the result of the guarantee price of electricity produced from RES in 2009 and the average TGC price in 2009. The TGC system does not favour PV technology as it is independent on the type and the size of different RES.
Additional support measures are low-interest loans and tax credits.

2.8 Romania

For the promotion of RES electricity, a quota system with TGC is active in Romania. TGCs are eligible for electricity produced from PV with less than 10 MW capacity [14].
The mandatory quota is increased from 5.26% in 2008 to 16.8% in 2020.
The minimum and maximum price of the TGC, over the 2008-2014 period, is between 27 € and 55 €. The number of TGCs issued depends on the technology used. The electricity produced by PV plants is remunerated with 4 TGCs for each MWh, for a 15 year period. Assuming a medium value for each TGC equal to 45 €, the total remuneration for the electricity produced by PV plants is equal to 0.180 €/kWh.
Electricity produced by PV in Romania is also eligible for the net metering system. In addition, PV technology in Romania is supported by investment subsidies and tax incentives.

2.9 Slovak Republic

The growth of the PV market in the Slovak Republic has been, until now, limited because of the too low FITs.
The main support measures carried out in Slovak Republic for the incentivization of PV electricity are: FITs, tax incentives and investment subsidies.
A new FIT scheme has been introduced in September 2009 [15]. All RES and high-efficiency cogeneration plants under 10 MW are eligible for the FIT system.
The new FIT scheme is based on a feed-in premium, paid on top of the basic electricity price. The new total FIT value for PV in 2009 is equal to 0.438 €/kWh and it is guaranteed for 12 years. FIT value is decreased by a fixed percentage in case the PV-owner receives financial subsidies, as highlighted in table 7.

TABLE 7: Level of decrease of the FIT related to the subsidies percentage

Subsidy (%) (total price of investment)	Percentage decrease of FIT (%)
up to 30	4
up to 40	8
up to 50	12
above 50	16

In addition, in Slovak Republic PV energy is supported by tax incentives.

2.10 Slovenia

The Slovenian PV market grew by more than 1 MW in 2008 because of the satisfactory FIT scheme and the good environmental conditions.
A new FIT system was implemented in Slovenia in October 2009 [16]. According to this scheme, FITs are differentiated depending on the size of the PV plant and the degree of building integration (ground-mounted systems, building integrated systems and systems added to buildings). The FIT value is paid for no more than 15 years.
Fixed FIT levels in Slovenia are outlined in Table 8, depending on the PV capacity and on the degree of building integration.

TABLE 8: New FIT values for electricity generated from PV plants in Slovenia, at the end of 2009

Rated power	Ground mounted systems (€/MWh)	Building integrated systems (€/MWh)	Systems added to buildings (€/MWh)
< 50 kW	390.42	477.78	415.46
< 1MW	359.71	437.03	380.02
< 5 MW	289.98	362.67	315.36

In addition, subsidies or loans with interest rate subsidies are also available.

3. THEORETICAL BACKGROUND

The comparative economical analysis is based on the calculation of the cash flow, the NPV and the IRR indices.

The cash flow can be expressed by adding algebraically all the costs C_i and all the profits P_i related to the generic t^{th} year, through the following equation:

$$C_t^* = \sum_i P_{i,t} - \sum_i C_{i,t} = F \cdot E_t + c_{kWh,t} \cdot E_t - u \cdot C_0 - C_{add}$$

where:

- C_0 is the initial investment cost (taking into account also the possible investment subsidies);
- F is the FIT or the TGC value;
- $c_{kWh,t}$ is the customer electricity price at the t^{th} year;
- u is a coefficient used to evaluate the maintenance and management cost, usually assumed 0.01 for PV systems [17];
- C_{add} is the annual insurance cost;
- E_t is the annual electricity produced by the PV plant.

In order to provide a realistic analysis, the cash flow was annualized by means of the classical expression:

$$C_t = \frac{C_t^*}{(1+i)^t} \quad (1)$$

where i is the Weighted Average Cost of Capital (WACC). The NPV and the IRR indices can be defined as follow [18]:

$$NPV = \sum_{t=1}^{N} \frac{C_t^*}{(1+i)^t} - C_0 \quad (2)$$

$$C_0 - \sum_{t=1}^{N} \frac{C_t}{(1+IRR)^t} = 0 \quad (3)$$

where N is the lifetime of the investment.

4. OPERATIVE HYPOTHESES

The comparative analysis of the different ways of implementing the PV support policies in eastern EU countries was carried out by considering a 1 MW ground-mounted PV system.
In the calculations, the following hypotheses are assumed:

- among the different supporting strategies carried out by the different countries (listed in section 2), tax credits are not considered, as related to the specific customer's financial situation;
- capital subsidies are not considered because of the too low cap that often is fixed;
- in the analysis, the Lithuanian case has been excluded, as no FIT or quota system is active at present;
- the annual energy produced by the PV system is considered totally transferred to the utility (the auto-consume is not considered);
- the mean operative efficiency of the PV system is considered equal to 80% (Italian Standard CEI 82-25, 2008);
- the WACC is considered equal to 3%;
- the annual average energy produced by the PV systems in eastern EU countries (per kW of PV

system) has the values given in Table 9, calculated using the data of the Ret Screen International Database (carrying out a mean among the different solar radiation values of the various major towns of each developing country);
- the total costs of the ground-based PV systems are assumed equal for all developing countries (4000 €/kW, VAT excluded);
- the annual maintenance and management costs are assumed equal to 0.5% of the total investment cost;
- the PV energy production is assumed to decrease every year by 0.8% of the total produced electricity;
- the annual insurance cost is considered the same for all countries and it is assumed to be equal to 10 € per kWp of the installed PV system;
- in those countries where two options are available for the remuneration of the produced PV energy (fixed FIT and feed-in premium), the fixed FIT option is implemented.

TABLE 9: Average annual values of the energy produced per kW by the PV systems for eastern EU countries

Country	Annual energy produced (kWh/kW)
Bulgaria	1120
Czech Republic	1020
Estonia	983
Hungary	1070
Latvia	990
Lithuania	980
Poland	918
Romania	1105
Slovak Republic	1030
Slovenia	1077

5. RESULTS AND DISCUSSION

The comparison of the different ways to apply support policies for the development of PV technology in the considered EU developing countries is now discussed. The cash flow during a specific 25 year period, for the considered 1 MW ground-based PV system is shown in figure 1. In table 10 are represented the PBP, the IRR and the NPV on the investments for the considered countries.

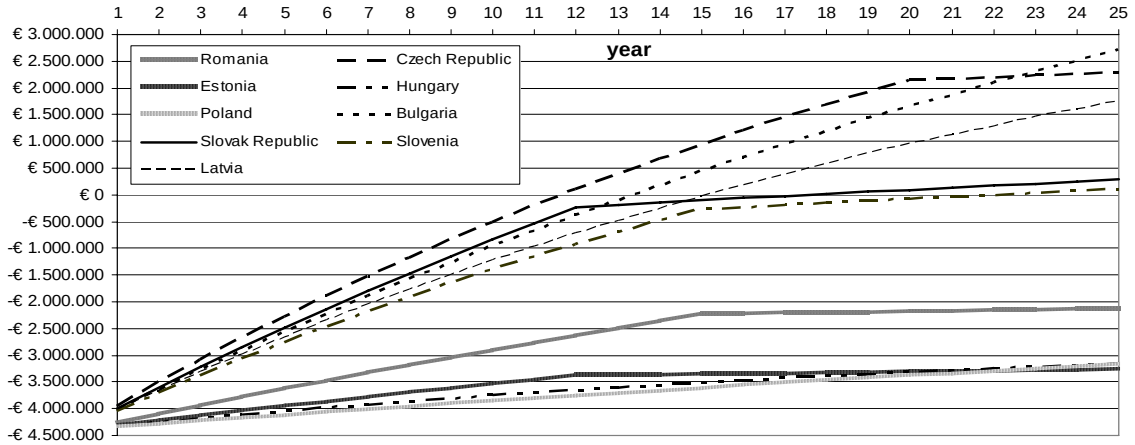

Figure 1: Cumulative cash flow comparison

TABLE 10: PBP, IRR and NPV for the developing EU countries

	PBP (years)	IRR (%)	NPV (k€)
Bulgaria	13	7.86	2700
Czech Rep.	12	8.07	2300
Estonia	-	-	-
Hungary	-	-	-
Latvia	15	6.43	1750
Lithuania	-	-	-
Poland	-	-	-
Romania	-	-	-
Slovak Rep.	18	3.87	280
Slovenia	22	3.31	110

The comparison of the different ways to apply support policies in eastern EU countries led to some interesting results that are discussed below:
- the Czech Republic and Bulgaria have, among the considered countries, the most profitable support strategies for large scale PV systems (lowest PBP and highest IRR and NPV), followed by Latvia. Essentially, this is due to the countries' high FIT value. In particular, the Czech Republic has the lowest PBP and Bulgaria the highest NPV. This difference is caused by the different duration of the financial incentives in the two countries;
- Slovak Republic and Slovenia are in the middle, with similar values of IRR and NPV. The PBPs, however, are distant because of the different duration of the financial incentives in the two countries;
- Romania, Estonia, Hungary and Poland have implemented less convenient support strategies for large-scale PV plants;
- the FIT scheme appears to be the most profitable support mechanism; indeed, countries, such as Romania and especially Poland, where a TGC system is implemented, have long PBP values.

The obtained results are consistent with the growth rate of the PV technology in the different countries.

6. CONCLUSIONS

This paper has presented a comparative economical analysis of the main supporting policies for promoting PV energy in eastern EU countries. As has been shown previously, the efficiency of these measures varies considerably depending on the details in each national law. In those member states where a FIT does not cover the expenses, the impact is very limited (as in Romania, Estonia, Hungary, Poland and Lithuania). Only member states in which support measures are good enough to recuperate the investment cost in a reasonable time, have PV installations increased competition in production and trade has developed substantially.
The results of the analysis presented in the paper do not cover all situations that can occur in practice, although the experimental evidence suggests that our results could explain most cases.
The comparative analysis carried out in this work could help:

- to evaluate the impact of the PV energy measures in eastern EU member states;
- to gain an insight into green energy companies by identifying potential PV markets and investigating the policy landscape across eastern EU countries.

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