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Research Paper

Financial and return aspects of solar power stations in Hungary

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Abstract: Electricity production is one of the major sources of global gas house gas (GHG) emission and is therefore responsible for climate change. In this context, renewable energy sources may have a significant role. Our research analyses the financial return of solar power stations in Hungary. Low-capacity (0.3-1.0 MW) solar power stations were examined to highlight differences between the former (mandatory take-over tariff, KÁT) and present (renewable energy subsidising scheme, METÁR) renewable energy take-over schemes regarding financial return. Our results show that both analysed projects have a positive financial return. However, the KÁT project has an excessive return rate, therefore the phasing out of the scheme can be considered justified.

Keywords: solar energy; renewable energy; financial return

1. Introduction

In September 2015 a new framework for sustainable development called Transforming our world: The 2030 Agenda for Sustainable Development (Agenda 2030) was adopted by 193 member states of the United Nations. One of the 17 sustainable development goals (SDGs) of the Agenda 2030 aims to ensure affordable and clean energy for all (SDG 13) (UN, 2015). In fact, clean energy production could contribute to achieving other SDGs, since there are significant overlaps between SDGs (Szennay et al., 2018). 40 percent of global gas house gases (GHG) are associated with electricity, gas and steam production and air conditioning. On the other hand, if electricity supply is taken into consideration only, then this sector is responsible for GHG emission to the highest extent (Koppány–Hanula, 2021).

Hungary's National Energy and Climate Plan (NECP) was developed according to guidelines by the European Union as part of Hungary's comprehensive strategy to fight against climate change (NECP, 2019). The NECP consists of goals and targets for the country for the period between 2021 and 2030. Hungary's goal is to achieve a 20 percent share of renewable energy sources in electricity production, which is envisaged to be achieved through solar energy: by 2030 solar energy use is planned to reach more than eightfold of the 2018 capacity level, whereas by 2040 the same rate of increase is foreseen to be 1600 percent.

An investment plan of such magnitude has significant costs: the implementation of the plan needs annual investments of 115 billion and financing of a sum of HUF 85 billion up until 2030 according to the estimates of Magyar Nemzeti Bank (Central Bank of Hungary) (Kendrács, 2020). This paper aims to analyse expected returns of private photovoltaic power stations, and examines whether governmental subsidy schemes are necessary for promoting private investments to meet decarbonising targets.

2. Theoretical background

2.1. Current state and limits of photovoltaic energy production in Hungary

Solar energy reaching the surface of the earth is not even: it is influenced by numerous factors including geographical location of the site, the meteorological situation, the slope and position of the solar panel. Global radiation – energy input on 1 square meter during a unit of

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time – measured on a horizontal surface totals between 1,150 and 1,332 kWh/square meter annually in Hungary, which makes it possible to utilise solar energy in a cost-efficient way using solar panels to generate electric energy (Pálfy, 2016). The irregularity of solar radiation presents the most important barrier of solar energy production, since the distribution of solar energy is uneven throughout seasons, and varies due to weather and other factors, thus solar energy production is not even. Energy storage technologies, which could balance temporary differences in energy demand and supply, are not advanced enough to store energy in an economic way on a large scale. Nevertheless, promising developments are likely to place in this area in the coming decades.

2.2. Current state and limits of photovoltaic energy production in Hungary

Since a comprehensive renewable energy act is non-existent in Hungary, regulations on renewable energies – similarly to the situation in the European Union – are defined in legal acts on energy. In the absence of a sectoral regulation, energy production related to renewable energy sources is regulated in the scope of regulations applicable to the type of energy concerned. Thus, the legal background and regulations pertaining to solar power stations can be found in Hungary's electricity law.

The utilisation and subsidisation of renewable energy sources, including solar energy, are regulated by Act CX of 2001, whereas the detailed Hungarian legal framework is set out in Decree No. 56/2002 (XII.29) GKM. As a result, the KÁP (mandatory take-over fund) system came into force, which served to support the production of electricity from renewable energy sources in Hungary between 2003 and 2007. The aim of the subsidisation is to improve energy efficiency, decrease energy usage and increase the share of renewable energy sources.

The sectoral regulation of electricity was renewed in 2007 through Act LXXXVI of 2007 and its implementing regulation. These documents set out the framework conditions for the newly introduced KÁT (mandatory take-over tariff) subsidy system for electricity production from domestic renewable energy sources, which replaced KÁP. Grant agreements under KÁT guarantee mandatory take-over of electricity produced at a predetermined price for the economic lifespan of solar power stations. In other words, the scheme significantly reduced producers' risks concerning take-over prices. Also, as prices of solar power stations continuously decreased, producers' price margins increased. Detailed rules concerning the system of different types of support are provided in Decree 389/2007 (XII. 23.) Korm. On the whole, KÁT appears to be an extremely favourable support scheme, which made solar power station investments truly competitive and profitable in Hungary, thus contributed to the rapid spread of solar panels in the country.

Guidelines of the European Commission published in 2014 put the subsidisation of renewable energy sources on a fundamentally new footing. According to the EU guidelines, take-over tariff systems are not supported instruments due to their market distorting effects, thus the phasing out of the KÁT started, so it could only be applied in its original form until 31st December 2016.

In accordance with the above-mentioned guidelines, a Hungarian government decree defining the new domestic support system was prepared and entered into force on 1st January 2017. Then, for a transitional period, it was still possible to request a mandatory take-over price – albeit only for solar power stations with a capacity under 0.5 MW –, but from April 2018 no new applications could be submitted, which meant that mandatory take-over for new entities was eliminated.

For full EU compliance, the 2016 decree was repealed by a new 2017 METÁR decree, which already follows the EU guidelines in most respects. For power stations of up to 0.5 MW but below 1 MW, until April 2019 there was another option to apply for a new type of subsidy without participation in tenders, but this option was also abolished due to an amendment to the legislation. As a result, this subsidy is currently only available in Hungary through an application and in the form of a green premium entitlement. In line with the new subsidy system, producers will have to sell the electricity they produce independently and directly on the market and will have to bear associated balancing energy costs.

3. Methodology

As a demonstration of the profitability and return of KÁT and METÁR, implementation projects of two solar power stations with a capacity of 499 kW, i.e. belonging to the low-capacity category, were analysed. Both of the projects introduced here are based on real figures but are presented anonymously.

The KÁT project was approved in 2016. Energy production started after the implementation at the end of 2018. The duration of the project grant agreement was 25 years and guarantees take-over prices. The project owner did not use external capital, only interest-free loan from the owners was provided. Therefore, project costs do not increase by instalments or interest payments, so the loan can be considered as a de facto shareholder's capital increase for a fixed period. Investment costs were also slight lower than the current market prices, since implementation was carried out in-house, using the resources of the project owner. The land required for the construction of the solar power station was provided by the owners free of charge, but in the scope of the simplification of the analysis' premises, investment costs do not include opportunity costs, and real estate rental costs were not incurred as operational cost, either.

The second project was started in 2019 and it won support at the first METÁR call: the take-over and the start of energy production are expected to take place at the beginning of 2021. The scope of the grant agreement is shorter than in the case of the KÁT project: only 15 years.

The most probable values typical of lower-capacity power stations were assumed in the calculations. The area intended for the construction of the solar power station is owned by the company, so no costs are incurred regarding the sale and purchase of land. The solar power plant is planned to be implemented by the company, and it is additionally assumed that the company installs self-marketed devices, so investment costs are presumably lower than current market prices. No decision has yet been made on the part of the investor regarding the sale of the produced electricity, so in this respect two scenarios are examined: (1) sale of produced energy in an association of a low number (15-20) of members directly on the Hungarian power exchange (HUPX), and (2) sale to an electricity trader company.

3.1. Key performance indicators

Five key performance indicators were calculated in the analysis of the two projects: (1) discounted payback period (DPB), (2) net present value (NPV), (3) internal rate of return (IRR), (4) levelized cost of energy/electricity (LCOE); (5) levelized revenue of energy/electricity (LROE).

DPB means the time until cumulated discounted cash flows of the project reach zero. While DPB considers cash flows only until the time of return, NPV includes the project's all discounted cash flows.

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

where

$C_t =$ cash flow of year t

$r =$ discount rate (weighted average of cost of capital [WACC] is used)

$n =$ lifespan of the project

IRR is the discount rate where net present value is equivalent to zero.

LCOE shows the specific cost of the power station over its lifespan. In other words, LCOE shows the present value of cost of a unit of produced energy, which makes it possible to compare production costs of particular energy sources.

$$LCOE = \frac{I + \sum_{t=1}^{n} \frac{M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

where

$I =$ investment cost

$M_t =$ operational and maintenance cost in year t

$F_t =$ fuel cost in year t (not applicable in the case of solar power stations)

$E_t =$ electricity produced in year t

To better understand the financial return of the projects, the use of LROE is recommended as a counterpart of LCOE. LROE presents a specific present value from the sales of the energy produced throughout the lifespan of the project, or in other words, similarly to LCOE, shows the weighted average of specific revenue.

$$LROE = \frac{\sum_{t=1}^{n} \frac{R_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

where

$R_t =$ revenue of year t

$E_t =$ electricity produced in year t

$r =$ discount rate

$n =$ lifespan of the project

The lifespan of solar power stations is assumed to be 15-30 years in the literature (see e.g., Bartek-Lesi et al., 2018, Pintér et al., 2018, Zsiborács et al., 2019). The lower figure, however, can be considered as economic rather than technical lifespan, since solar panels are generally in good condition even after 15 years of operation and they can be sold in the secondary market at reasonable prices (Zsiborács et al., 2019). In the scope of this analysis, however, the quite higher figure of 25 years is used.

3.2. Discount rate

The discount rate used in the present value calculation was established on the basis of the Methodological Guide of the Hungarian Energy and Public Utility Regulatory Authority (HEA) (HEA, 2015). According to the Guide, the discount rate is equivalent with the weighted average of cost of capital (WACC).

$$r = r_e \times E + r_d \times D \times (1 - T)$$

where

$r =$ discount rate – weighted average of cost of capital (WACC)

$r_e =$ cost of equity, i.e. the expected return of shareholders' capital

$E =$ share of equity in investment cost

$r_d =$ cost of debt

Since external capital is used neither in the KÁT nor in the METÁR project, henceforward only the cost of equity is calculated. According to the Methodological Guide of HEA (2015), the cost of equity is determined on the basis of the Capital Asset Pricing Model model, taking into consideration the risk-free rate and the market risk premium weighted with the business risk (beta) (e.g. Brealy–Myers, 2011).

$$r_e = r_f + \beta \times ERP$$

where
$r_e =$ cost of equity, i.e. the expected return of shareholders' capital
$r_f =$ risk free rate
$\beta =$ sectoral beta, taking into consideration the leverage
$ERP =$ market risk premium

The yield of Hungarian treasury bonds denominated in Hungarian forint with 15 years of maturity was used as the proxy of risk-free rate, which was 2.69% between November 2019 and October 2020 in average (MNB, n.d.). For the sectoral beta, we used the unleveraged beta value (0.57) published by the HEA methodological guide (HEA, 2015). This beta figure is derived from Damodaran (n.d.) and relates to the sectoral (average) beta of European electricity companies. Market risk premium was determined on the basis of the values published by Damodaran (n.d), which is 4.9% in the case of developed markets (HEA, 2015). Thus, the cost of capital is 5.48%.

3.3. Estimation of costs

Investment cost – in the case of having available land – consists of two parts: (1) cost of components (e.g., cables, transformers, etc.) and activities (e.g., administration, etc.) necessary for implementation, the so-called balance of system (BoS) cost, and (2) the price of solar panel equipment (panels, inverters). Overall, investment costs have fallen dramatically in recent years, given the drastic fall in equipment prices (see Appendix A). Real and estimated costs of two implemented solar power stations were taken into consideration in the calculation. Based on these, the investment cost of the KÁT and the METÁR project is HUF 115.1 and 134.7 million, respectively.

Security and insurance costs are needed for continuous operation, and maintenance costs also emerge. In addition, of course, the usual administrative and utility costs are also incurred. On the other hand, operational and maintenance costs are low compared to the use of renewable energy sources as solar power stations have only a small number of moving parts (REKK, 2018) and land management and maintenance are not especially costly.

Operational and maintenance costs make up generally 1 percent of investment costs (IEA, 2018). This figure, however, is higher in the case of the analysed projects, and are between 1.29 and 1.97% (see Appendix B). Since technology and therefore producing costs of the examined projects are similar to the average, higher-than-average operational and maintenance costs may be a consequence of the costs of different business models.

Out of the three analysed projects, the KÁT project has the lowest annual operational cost since neither electricity exchange cost nor balancing energy costs have to be taken into consideration. Scheduling service fee make up the highest figure, where the commissioned company undertakes to fulfil the scheduling obligations of the solar power station prescribed by law, i.e. to prepare the production forecast to be submitted to MAVIR Hungarian Independent Transmission Operator Company Ltd., and it bears the burden of surcharges resulting from the inaccuracy of the schedule as stipulated by law.

In the case of METÁR projects, the preliminary determination of operating and maintenance costs is currently one of the most difficult tasks of the calculation due to the different costs of sales methods and the determination of the amount of balancing energy. Two sales methods were taken into consideration. First, when the power station sells energy directly on HUPX. In this scenario, two items were calculated: (1) the market costs, which – assuming joint efforts by 14-15 low-capacity solar power stations and their coordinated entry into the market – is HUF 1/kWh; and (2) balancing energy cost, where a cost of HUF 1.5/kWh was used as a basis for calculation, relying on the assumption that the members of the association place great emphasis on schedule accuracy in order to minimize costs. The other option is for the operator to enter into a 15-year-long contract with an energy trading company, in the scope of which the balancing cost of the trading company is also taken over. For this reason, the company requests a total commission fee of HUF 3/kWh compared to the average price of HUPX DAM adjusted to production, so the sales commission accounts for more than 70 percent of the operating costs.

In the calculations, an annual inflation of 3 percent in operating and maintenance costs has been taken into account, given that the price increase is originally included in the sales price in line with the legal regulations.

3.4. Revenue estimation

According to expert estimations, a solar power station with a nominal capacity of 0.5 MW under the current technical conditions produces an average of 700-720 MWh/year in Hungary. The realised sales revenue of produced energy depends on the grant agreement. Since takeover prices are high and guaranteed, the KÁT-project offers a rather high sales revenue. In the case of METÁR-projects, the examined two sales methods result in different sales revenues. This difference, however, is not significant.

In the case of direct sales on the HUPX, the price level is determined by the sum of the actual sales price and the premium provided under by the grant agreement. 85 percent of the market prices was used as a sales price calculating with the expectation that the price level reached by the producers' association would slightly be below market prices. In the case of commission sales, the selling price is the average price of the HUPX DAM in line with the contract. If the subsidy surcharge is added to this, the sum of the two gives the actual price level. The prices determined this way were multiplied by the amount of energy produced, which – this way – resulted in the sales revenue.

In general, both the guaranteed KÁT price and the METÁR premium are adjusted by the annual consumer price index published by the Hungarian Central Statistical Office minus 1 percent point each year. Actual prices are published through public communication by the HEA at the beginning of each year. In the analysis, prices published by the HEA were used in the years between 2016 and 2020, while in the revenue forecast – based on the forecast of the European Electricity Market Model (REKK, 2019) – a price index of 2 percent was taken into consideration, which means an annual price change of 1 percent.

4. Results

Our results show that – based on the methodology used – all the three projects are financially profitable, but key performance indicators vary significantly (see Table 1).

Table 1. Key performance indicators of analysed projects. *Source: own calculation*

Measure		KÁT-project	METÁR-project	
			HUPX sales	Commission sales
Discounted payback period	years	8	17	15
Net present value	HUF thousand	155 618	18 311	30 861
Internal rate of return	%	18.25%	7.35%	8.52%
LCOE	HUF/kWh	16.43	21.25	20.65
LROE	Ft/kWh	36.07	23.05	23.89
Difference between LROE and LCOE	HUF/kWh	19.64	1.80	3.25

The discounted payback period of the KÁT project is less than 8 years, whereas the two METÁR projects have longer figures: 17 years in the case of direct HUPX sales and 15 years with respect to commission sales. Differences can be explained by the realised sales revenue and by related costs. IRR shows that the return rate of KÁT project is rather high compared to its risk (18%), but the two METÁR projects also have significantly higher IRR than their cost of capital (5.47%). This means that solar power stations are profitable under market conditions, i.e. if their investment costs are not subsidised, and if they have a competitive rate of return compared to their expected risks.

Furthermore, LCOE shows the present value of unit cost of energy production during the lifespan of the investment. LCOE can be considered as a constant revenue that must be realised during the lifespan of the project to cover all related costs (REKK, 2018). The figure of the KÁT project is the lowest, since the take-over price is guaranteed, while network intake and related costs are not borne by the operator. The LCOE figures of the two METÁR projects are significantly higher, which is the risk premium of the uncertainty of network intake.

The difference between LROE and LCOE, namely the present value of unit margin during the lifespan of the projects, is caused by the fact that while the LROE of METÁR projects depends on market prices, the KÁT project is independent from it as take-over prices are regulated on a higher-than-market price level. In other words, the high return of the KÁT project can be considered as subsidisation to promote investing in renewable energy sources, but since investment costs of solar power stations have fallen significantly, such subsidisation can be considered too generous in the given circumstances.

4. Conclusions

This research analysed the financial return of solar power stations. Low-capacity (0.3-1.0 MW) solar power stations were examined to highlight differences between KÁT and METÁR schemes regarding financial return. In the case of the METÁR scheme, two versions were taken into consideration: (1) direct sales on the Hungarian power exchange (HUPX) assuming joint efforts by 14-15 low-capacity solar power stations and their coordinated entry into the market, and (2) the sale on a commission basis to an energy trading company. Our results show that all three projects have positive financial returns. The KÁT project, however, has an excessive return rate, therefore the phasing out of the scheme can be considered justified. The KÁT project has an IRR figure of 18.25%, while this value is much lower (7.35 and 8.52%) in the case of the two METÁR projects. Although the existence of the used land was considered a given in the calculations, we believe that positive return also realises if land purchase has to be made.

In summary, it can be stated that although METÁR places producers in a significantly more unfavourable position compared to KÁT, the available return in the case of METÁR is still favourable compared to the undertaken risk. Due to the previous extremely high profitability, the interest and willingness to submit METÁR applications are intense, but the experience of the coming years will provide an answer as to whether the supported investments will be realized and if they can survive in free market conditions. It is feared that small producers will negatively be affected by these measures. If the conditions of support remain unchanged, it is also possible that this capacity size will no longer be profitable and that the size of solar power plants will shift towards industrial magnitudes.

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Appendix A

Detailed investment cost of a solar power station with a capacity of 0.5MW in Hungary, based on figures of implemented investments and tenders.

Cost type	Cost subtype	Description of cost	Figures 2015*	Figures 2016*	Figures KÁT project, 2018**	Figures METÁR project
BoS cost	Administration	Other administration	2 480	2 480	2 480	-
		Land register	12 500	12 500	12 500	-
		Commission and fees	1 124 499	1 124 499	1 124 499	-
		Planning	4 108 947	5 400 000	848 000	-
	Other infrastructure	Security system	4 444 000	4 875 000	1 669 993	-
		Fence	1 891 000	2 468 708	2 468 708	-
		Road building	560 201	560 201	560 201	-
	Consols	Components	17 725 000	29 760 000	12 812 166	-
		Field works	2 284 600	8 705 000	1 826 500	-
	Implementation	Components	12 314 620	2 015 000	84 133	-
		Other services	0	0	96 000	-
		Cabeling	15 387 900	7 232 500	5 067 126	-
		Field works	1 050 540	5 175 000	480 000	-
	Transformer	Transformer	28 500 000	17 595 000	10 698 000	-
BoS cost total			89 406 287	84 925 888	37 750 306	-
Device cost	Inverter		21 556 864	17 200 000	11 654 000	-
	Solar panels		104 975 831	87 360 000	65 705 412	-
Device cost total			126 532 695	104 560 000	77 359 412	-
Investment cost total			215 938 982	189 485 888	115 109 718	134 730 000
Specific cost of investment (HUF/kW)			432 743	379 731	230 681	270 000

*general implementation based on tender prices

**based on analytic data of own implementation

Appendix B

Operation and maintenance cost of analysed investments based on figures of first operating year and assumptions.

Description	KÁT project	METÁR project	
		HUPX sales	Commission sales
Administration fees	150 000	150 000	150 000
Insurances	155 000	155 000	155 000
Sales commission	0	0	2 130 000
Maintenance cost	300 000	300 000	300 000
Balancing energy cost	0	1 065 000	0
Utility cost	70 000	70 000	70 000
Scheduling service	660 000	660 000	0
System usage and radio communication fee	150 000	150 000	150 000
Electricity exchange cost	0	710 000	0
Total	1 485 000	3 260 000	2 955 000
Operation and maintenance cost as a percentage of investment cost	1.29%	2.18%	1.97%

Source: figures of implemented investments and assumptions