Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 1, rok 2007, ročník LIII, řada strojní
článek č. 1544

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TECHNICAL AND ECONOMIC ASPECT OF WIND ENERGY UTILIZATION

TECHNICKO-EKONOMICKÉ ASPEKTY VYUŽÍVÁNÍ VĚTRNÉ ENERGIE

Abstract

The paper deals with possibilities of electricity production from wind power plants in the Czech Republic. The technical economics parameters of wind turbines and results of paced studies in that branch are using to this purpose. The most important parameter - capacity utilization factor is applied to evaluation.

Abstrakt

Příspěvek se zabývá možnostmi generování elektrické energie z větrných elektráren v České republice. Pro tento účel jsou využity závěry studií zpracovaných v této oblasti a definovány technicko-ekonomické parametry větrných turbín. Jako hlavní parametr pro hodnocení je požit součinitel využití instalovaného výkonu.

1 INTRODUCTION

Wind power plants started to be built in the Czech Republic in 1990s. In the majority of cases there concern about refurbished imported power plants or about unreliable Czech-made power plants. Next big problem was that these power stations were situated without detail analyses or long-last testing of wind energy potential in the selected locality.

This is also one of reasons, why the majority of the first installations had very low utilization and reliability and why there were dismantled during short time of performance.

The change came after 2003, when modern wind power stations started to build. One of the first installations of modern wind power stations was built in Jindřichovice pod Smrkem in 2003. Although detail analyses were done, this power station does not achieve a presumptive a capacity utilization factor above 20 % but only about 11 %.

At present time the stations with 1,5 MW and higher electricity nominal power are built. In 2010, the presumptive sum of nominal power of wind power plants in the Czech Republic is about 500 MW.

2 BASIC TECHNICAL-ECONOMIC PARAMETERS OF WIND POWER STATIONS

Nominal power P_i [W] is ordinarily identical to maximal power that the station is able to supply to the net. At the nominal power, the station can work often only several hours a year. Hence, this parameter is for analyses of utility value of monitored source unsuitable.

However, this parameter notifies distributors on the peak power supply that it can be used on the Czech law for the cover of own losses in electricity transmission system only.

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Capacity utilization factor k_r [-] is ratio of real (W_r [Wh]) and theoretic sum of electricity. The theoretic sum is calculated like a sum of electricity that would station produce if it would work 8760 hour a year at the nominal power

$$k_r = \frac{W_r}{P_i.8760} \quad (1)$$

This coefficient is a significative parameter reflecting an intensity of investment utilization and markedly influences their cost effectivity.

The annual electricity production of a power station can be forecasted when the coefficient is known or estimated.

Annual mean power P_r [W] is solved from real sum of electricity production W_r.

$$P_r = \frac{W_r}{8760} = k_r.P_i \quad (2)$$

When there is electricity production W_r represented in the unit [Wy] (Watt-year) the annual mean power P_r and electricity production W_r are numerically identical ($P_r = W_r / 1$)

Next parameters

Annual electricity production	[MWr]
Investment	[mil. CZK]
Electricity price	[CZK/kWh]
Static payback period	[year]
Dynamic payback period	[year]
Net present value	[mil. CZK]

3 ELECTRICITY PRODUCTION FROM 2001

According to information [4] there is evaluated an accrual of wind energy exploitation in period from 2001 to 2007.

Tab.1 Data of wind power plants in the Czech Republic

Year	Nominal power	Electricity production		Capacity utilization factor
	[MW]	[kWy]	[GWh]	[%]
2001	1,2	22,8	0,2	1,9
2002	5,4	183,6	1,6	3,4
2003	9,9	455,6	4,0	4,6*
2004	17,8	1228,2	10,7	6,9*
2005	22,0	2431,5	21,3	11,0*
2006	41,7	5614,1	49,2	13,5*
2007**	43,6	1408,9	12,3	

* these data are solved from final annual report and it is not subsumed that some stations started a production during the year

** to January 31, 2007

4 ANCILLARY SERVICES

Ancillary services (AS) serve a provision of dependability of transmission system operation. These services contain unit primary frequency control, unit secondary and tertiary power, quick-start 10 minute reserve control and so on.

Owing to an accrual sum of nominal power of wind power stations, the range of these services must increase which means that the costs for these services increase too.

According to [6] the accruing costs AS is solved like

$$P_{AS} = k_{AS} \cdot P_i \tag{3}$$

where k_{AS} is a coefficient of the accruing AS due to the accrual of wind plant installations (for 2006, k_{AS}=0,22), P_i is sum of nominal capacities of wind plants.

In the frame of accruing costs P_{AS} (in 2006) the unit secondary control partakes 30 %, tertiary control 35 % and dispatch reserve 35%.

5 ECONOMICS ASPECTS OF WIND POWER PLANTS EVALUATION

Generation of the electricity from renewable sources is supported by the government of the Czech Republic. One of the reasons is to fulfill the commitment regarding share of electricity generated from renewable sources at the total electricity generation. Signing the Kyoto agreement, the EU accepted the obligation to increase this share up to 21 %. In the Czech Republic, the present 4 % share should be increased by the end of 2010 to 8 %.

5.1 Forms of support of renewable electricity generation in the Czech Republic

There exists system of supporting electricity generation in renewable sources. This system has a few forms (tax, accounting, financial, etc.) with the main goal to support the electricity generation in renewable sources. Among the most important are:

a) Act No. 180/2005 about the support of electricity generation in renewable sources – guaranteeing that all the output generated in renewable sources must be bought back by distribution companies for a price stated by the energy government authorities. Moreover, this act states minimal electricity prices guarantying 15 years payback of investments in such projects.
b) Law No. 586/1992 – Law of Income tax, guarantying that during the first 6 years of operation, no tax is paid on revenues from sales of electricity generated in renewable sources.
c) Law No. 338/1992 – Real Estate tax, guarantying no tax on real estates used for electricity generating from renewable sources.

Moreover, the State Environmental Fund of the Czech Republic provides for investors with the intention to invest in selected projects subsidized bank loans. By the end of the year 2005, there were loans provided by this fund with preferential interest rate of 1,5% or 4 % p.a., 12 years of maturity and the option to defer the first installment up by 2 years. Moreover, non profit subjects operating such project could, in addition, apply for nonrepayable subsidy up to 30 % of the total investment outlay. At present, no of these financial supports for wind power plant are provided.

5.2 Valuation methodology

Generally, there exist several methods for project valuation; their application differs in assumptions for their possible employing.

The most frequently methods are Net Present Value (NPV) and payback method.

5.2.1 Net Present Value

This method relies on the comparison of the present value of cash flow generated by the project and investment outlays over the project life time, which can be mathematically written as follows,

$$NPV = \sum_{t=0}^{N} \frac{FCF_t}{(1+R)^t}, \tag{4}$$

where *FCF* is free cash flow generated by project in a given year *t*, *N* is expected years number of operation and *R* is cost of capital. If the NPV is positive, the investment should be accepted, otherwise it is better to reject it.

There are two basic forms of NPV calculation, which differs in the way, how the free cash flows are defined.

In this study, NPV version on the basis of equity capital is applied, where free cash flow are defined as cash flows for equity holders (investors), which are discounted by the cost of equity. In this case, general equation (4) has this form,

$$NPV = \sum_{t=0}^{N} \frac{FCFE_t}{(1+R_E)^t}, \tag{5}$$

where *FCFE* is free cash flow to equity (investors) and R_E is cost of equity.

FCFE in a given year of operation can be expressed as a difference between projected cash inflows and outflows, i.e.,

$$FCFE_t = EAT_t + DEP_t - INV_t + D_t - \Delta WC + S_t^+ - S_t^-, \tag{6}$$

where *EAT* is net profit after taxation in a given year, *DEP* is depreciation, *INV* is investment outlay, *WC* is net change in working capital, *D* is nonrepayable subsidy, S_t^+ is investment credits accepted in a given year and S_t^- investment credit installments in a given year. Net profit after taxation generated by the project is defined in this way,

$$EAT_t = \left(\mathrm{Re}\,v_t - N_{oper..} - DEP_t - N_{fin..}\right)\cdot\left(1-d\right), \tag{7}$$

where *Rev* are revenues in a given year, $N_{oper.}$ are operational costs, $N_{fin.}$ is project financial costs (interest paid on bank loan) and *d* is tax rate.

5.2.2 Payback method

Payback considers the initial investment outlay and the resulting annual cash flow. The payback period is the amount of time (usually measured in years) to recover the initial investment in an opportunity. Unfortunately, the payback method does not account for savings that may continue from a project after the initial investment is paid back from the profits of the project, but this method is helpful for a “first- cut” analysis of a project.

There exist two basic forms of playback method: simple (static) and discounted (dynamic) playback method.

In the case of static payback method, initial investment outlay and nominal future cash flow are compared. The goal is to find the time, $N_{static,}$ when holds,

$$INV = \sum_{t=1}^{N_{static}} FCFE_t \tag{8}$$

in the case of discounted (dynamic) version, where one works with discounted cash flow, the number of years, when the initial outlay is recovered, $N_{discounted}$ is given by this formula,

$$INV = \sum_{t=1}^{N_{disc.}} \frac{FCFE_t}{(1+R_E)^t}. \tag{9}$$

Investor should accept the project, if payback period is shorter than the total number of years in operation (life time of the project). Generally the shorter the payback period, the higher liquidity of the project.

5.3 Illustrative example

The aim of this part is to present valuation and sensitivity analysis of wind power plant under the conditions of the Czech Republic. It is supposed that the total output of plant is 2 MW, total investment outlays is 60 mil. CZK, operational cost of production is 1,8 mil. CZK per year. Moreover, it is supposed, that the price of electricity given by Energy Regulatory Office is 2,46 CZK/kWh for project started in year 2007. The expected number of years in operation is 20, average capacity utilization is 20 %. Project is financed both by equity (20 mil. CZK) and by bank loan (40 mil. CZK).

Since 2006, it is not necessary to distinguish between subject operating wind power plants subject A and B) since no financial support is provided by State Environmental Fund of the Czech Republic.

Results of calculation are apparent from Figure 1.

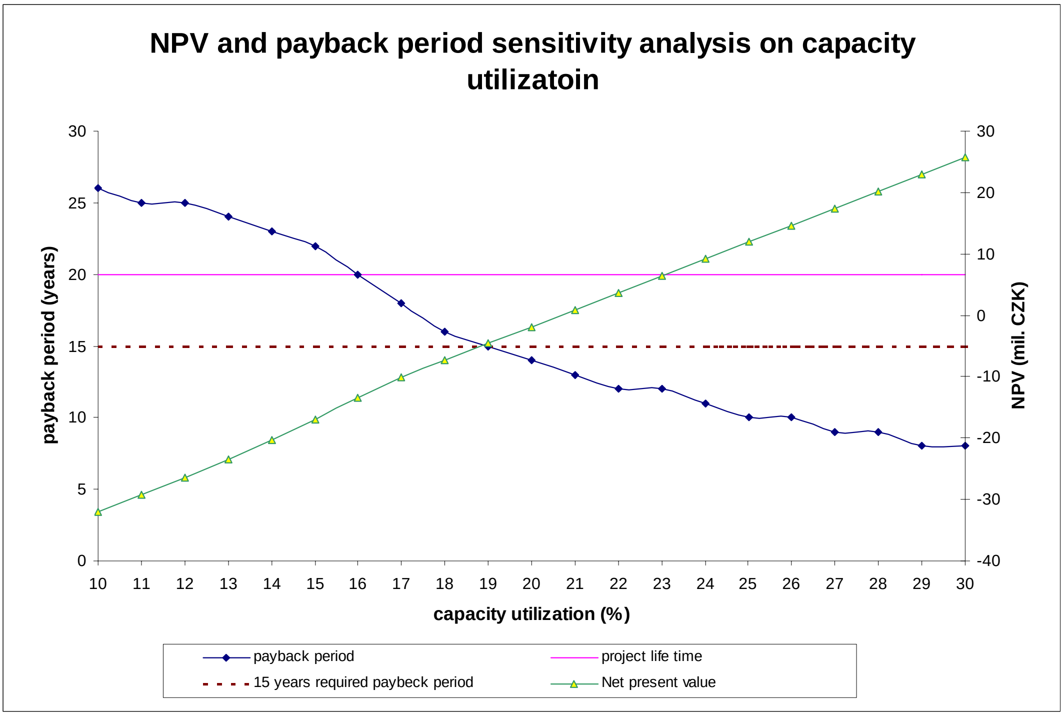

Fig. 1: Results of valuation and sensitivity analysis

Furthermore, critical values ensuring 15 years payback period and null value of net present value criterion were calculated. Results are summarized in the following Table 2.

Tab. 2: Critical values of project

criterion	Unit	NPV = 0	Payback period = 15	
			static	dynamic
electricity price	CZK/kWh	2,54	2,31	3,92
operational cost	mil. CZK/ year	1,53	2,27	0 *
capacity utilization	% /year	20,67	18,81	31,9

* Zero operational costs do not even ensure dynamic payback period before expect life time of the project. It would be achieved for operational costs of -2,3 mil CZK/year, which has no economical sense

In the end, sensitivity of Net present Value and payback period on the equity/debt structure was analyzed, see Figure 2.

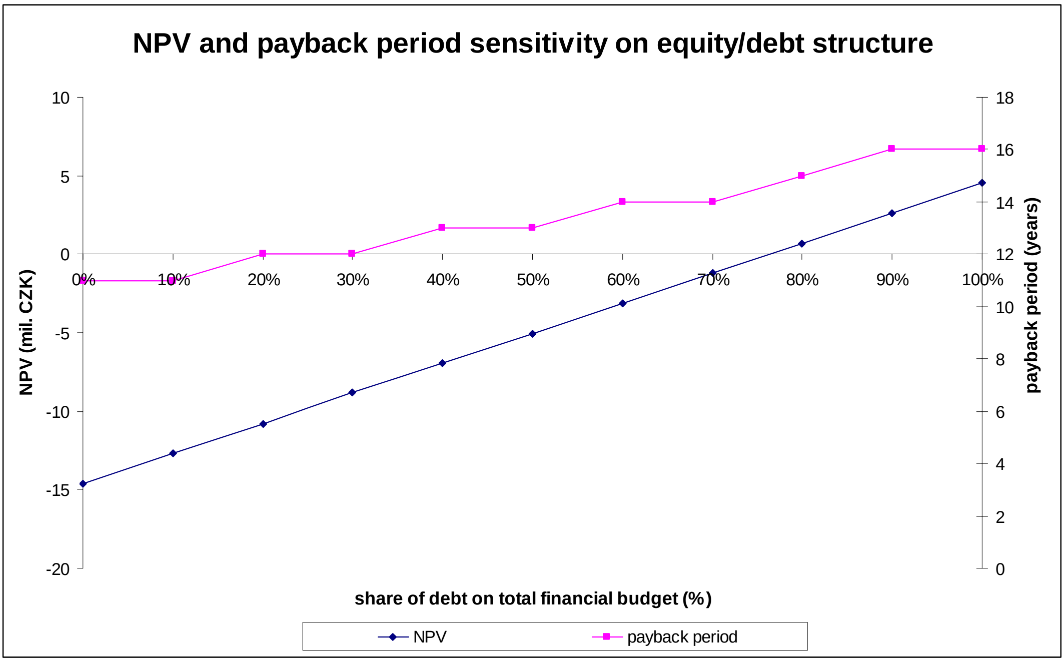

Fig. 2: NPV and payback period sensitivity on equity/debt structure

6 CONCLUSION

There is popularly known that the Czech Republic undertook to reach of 8 % renewable energy share of the total electricity consumption by 2010. The share of wind energy on this consumption is estimated about 0,87 % when it is assumed sum nominal power 500 MW and the capacity utilization factor 15 %.

However, the non-sophisticated development of wind energy can negative effect to the electricity grid and can increase a possibility of a large-scale disruption in electric power grid supply (blackout). The production of electricity from non-regulated energy sources is acceptable only to specific level. More extensive operation of wind and solar power stations with a stochastic course of power delivery to the grid coerces the cost increase to ancillary services. The next installations of quick-start 10 minute reserves (peak hydro and gas turbine power stations) will be needed considering to high variability of power delivery from non-regulated energy sources even if the local delivery asynchronisms can decrease the peaks.

The paper was created in the frame of solution at research programme MSM 6198910007 „Research of the reliability of power systems in connection with non-traditional ecological sources of energy and valuation of unsupplied energy “.

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