Umwelt Bundesamt

Energy management systems in practice

Annex

Payback period as a benchmark for energy efficiency actions

Potential investment projects – especially those with a strong technical character, such as energy related projects – are often assessed based on the results of payback period calculations. By limiting the payback periods to e.g. three years (often the rule) this method is regularely used to either reject or approve proposed projects. However, even the use payback calculations that acknowledge the time value of money (dynamic or discounted payback period) is highly problematic, especially when evaluating energy efficiency-oriented investment projects. Why?

The dynamic payback period is the point in time at which the discounted returns of an investment (for example, energy cost savings) cover the discounted outpayments exactly. At this point in time, the net present value is zero. Usually, the net present value increases from this point on. The discounted payback period can therefore be seen as the break-even point for an investment. The not-discounted version of the payback calculation bears the same message, but ignores interest and compound interest as well as fluctuations in future payments. It is therefore not recommended for realistic investment calculations.

The discounted payback period is determined by progressively adding the in- and outpayments for each period – starting with the present (period 0). In order to calculate the present values, the balance of the payments of a period is discounted to the present (period 0). Adding up the present values of all considered periods results in the **net present value** of the investment (see Table 1, line 9).

In Table 1 (line 7), the net present value is first calculated based on the sum of the present values of the first two periods (here: € -304,762), then on that of the first three periods (€ -214,059), then of the first four periods, and so on. Beginning with period zero, the number of periods taken into account is successively increased to finally determine the point at which the period-specific net present value results in a zero value (between those periods in which the plus or minus sign of the net present value changes). This point in time is known as the payback period, in our example between the fourth and the fifth period (see Table 1, line 7).

Table 1: Determination of the payback period for a model with 10 payment periods at an interest rate of 5%

A	B	C	D	E	F	G	H	I	J	K	L	M
2	End of period	0	1	2	3	4	5	6	7	8	9	10
3	Payout	-400,000										
4	Repayment		100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
5	Balance	-400,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
6	Present value	-400,000	95,238	90,703	86,384	82,270	78,353	74,622	71,068	67,684	64,461	61,391
7	Net present value depending on the period	-400,000	-304,762	-214,059	-127,675	-45,405	32,948	107,569	178,637	246,321	310,782	372,173
8	→ Calculation from line 7:	=sum (C6:C6)	=sum (C6:D6)	=sum (C6:E6)	=sum (C6:F6)	=sum (C6:G6)	=sum (C6:H6)	=sum (C6:I6)	=sum (C6:J6)	=sum (C6:K6)	=sum (C6:L6)	=sum (C6:M6)
9	Net present value NPV (sum of line 6)	372,173										
10	Payback period [years]						4.6					

(Source: Own illustration)

The system-inherent problem of this method lies in the fact that for the determination of the payback period only those cash flows are used, which occur during that period, i.e., until the payback period has been reached (here: up to 4.6 years). As a result, only these cash flows are taken into account, while all other cash flows are irrelevant for the result. As an example, Table 2 illustrates how all payments in periods 6 to 10 could be deleted from Table 1 without affecting the payback period (however, this would of course affect the net present value), as they do not occur until after the payback period has been reached. These cash flows are therefore systematically disregarded.

Table 2: Illustration of the irrelevance of payments after the payment period has been reached

End of period	0	1	2	3	4	5	6	7	8	9	10
Payout	-400,000										
Repayment		100,000	100,000	100,000	100,000	100,000					
Balance	-400,000	100,000	100,000	100,000	100,000	100,000					
Present value	-400,000	95,238	90,703	86,384	82,270	78,353					
Net present value depending on the term	-400,000	-304,762	-214,059	-127,675	-45,405	32,948					
Net present value NPV	32,948										
Payback period [years]						4.6					

(Source: Own illustration)

The negative impact of disregarding cash flows that occur after the payback period has been reached becomes particularly clear when costly dismantling, downsizing, renovation or modernization costs (e.g., nuclear power plants, repowering of wind turbines, etc.) must be carried out at the end of an installation's service life – as shown in Table 3 in an additional period 11. Those costs are systematically excluded from the payback period calculation, just as all other payments are excluded from the payback period onward (as can be seen by the fact that the payback period does not change when these payments are taken into account).

Table 3: Illustration of the issue of systematic disregard of all cash flows over an investment's lifetime

End of period	0	1	2	3	4	5	6	7	8	9	10	11
Payout	-400,000											
Repayment		100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	
Dismantling or repowering												-700,000
Balance	**-400,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**100,000**	**-700,000**
Present value	**-400,000**	**95,238**	**90,703**	**86,384**	**82,270**	**78,353**	**74,622**	**71,068**	**67,684**	**64,461**	**61,391**	**-409,276**
Net present value depending on the term	**-400,000**	**-304,762**	**-214,059**	**-127,675**	**-45,405**	**32,948**	**107,569**	**178,637**	**246,321**	**310,782**	**372,173**	**-37,102**
Net present value NPV	**-37,102**											
Payback period [years]						**4.6**						

(Source: Own illustration)

The example illustrates that payback period calculations are incomplete, as they do not take into account all relevant cash flows. The method should therefore not really be considered an investment calculation for decision-making. The incompleteness especially plays a role in long-term investment projects. And these usually include investments in energy efficiency. **The payback period method is therefore unsuitable as a basis for decision-making regarding energy efficiency actions. Rather, decision-makers should rely on comprehensive net present value calculations.**

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