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DISCOUNT RATES FOR THE EVALUATION OF ENERGY PROJECTS – RULES AND PROBLEMS

Abstract. The amount of discount rate vitally influences the economic efficiency of investment projects – its range relates to the associated risk factors. Estimating the discount rate dedicated to a specific project has for a long been the subject of numerous research works and sector studies. The capital asset pricing model (CAPM) is considered to be an analytically-proper discount estimation model. Nonetheless, the model is burdened by several flaws, thus no indisputable or definitive methodology allowing the long-term determination of discount range has been created. The hereby article presents the problem with regards to the energy production sector.

Keywords: energy projects, discount rate, WACC, CAPM

STOPY DYSKONTA W OCENIE EFEKTYWNOŚCI INWESTYCJI ENERGETYCZNYCH – REGUŁY I PROBLEMY

Streszczenie. Wysokość stopy dyskonta w newralgiczny sposób wpływa na efektywność ekonomiczną projektów inwestycyjnych – jej miara związana jest z towarzyszącymi im czynnikami ryzyka. Szacowanie stopy dyskonta dedykowanej konkretnemu przedsięwzięciu od dawna jest przedmiotem wielu prac naukowo-badawczych i opracowań sektorowych. Za odpowiedni analitycznie model szacowania stóp dyskonta uznawany jest model wyceny aktywów kapitałowych (CAPM). Model ten przedstawia jednak wiele wad i jak dotychczas nie udało się, w sposób bezdyskusyjny i definitywny, opracować metodyki umożliwiającej determinowanie miar dyskontowych. Artykuł przedstawia zarysowany problem na przykładzie energetyki.

Słowa kluczowe: projekty energetyczne, stopa dyskonta, WACC, CAPM

1. Introduction

The assessment of the economic efficiency of energy investment projects is mostly performed by means of the so-called income-based approach in the form of discounted cash flow analysis (DCF). The algorithm in this method focuses on the cash flows which are forecast for the overall lifetime of the project. The aim of DCF analysis is to calculate and evaluate investment feasibility indicators – mostly net present value (NPV) and internal rate of return (IRR).

The discounted cash flow analysis assumes that an investment project will be carried out in accordance with a single, anticipated scheme of events, which includes rational prognoses of primary technical and economic-financial data for the investment period and operating activity. Due to this, the DCF requires the greatest possible amount of reliable information concerning future management within the project.

In the case of DCF, the investor currently considering involvement of their capital in an industrial project is mostly interested – as it is in the case of alternative investments – in getting answers to the most pressing questions – i.e. about the time of anticipated benefits and the probability of them occurring. Naturally, a rational investor prefers their capital to be ‘frozen’ for the shortest possible periods of time, since only actual possession of money allows it to be invested in further investment opportunities. A patient investor, however, may renounce quick profits in the hope of higher return of investment somehow compensating both the waiting and the uncertainty. The rate of return is called the own equity cost or the discount rate which – depending on the situation – may take different names (e.g. social discount rate, hurdle rate, minimum acceptable rate of return, MARR, or risk-adjusted discount rate, RADR).

When assessing an uncertain project, the discount rate plays a key role – it is a parameter that allows you to ascertain the value of future cash flow streams through the perspective of today. The parameter reflects investor’s time and risk preferences. The impact of the discount rate on the gross present value, PV, of the project has been presented in Fig. 1 – we can see that PV generally decreases with the increase of the discount rate; this impact is all the more stronger with the discount rate getting higher and the project lifetime longer. This means that regarding long-term projects – such as power generation investments – the use of high discount rates in the DCF analysis causes cash flow streams in the initial phase of the project to take a dominant role when it comes to the present value.

Due to the importance of the discount rate, assessing its level for the sake of investment projects, carried out by means of the DCF method, seems a priority. Both science and industrial practice have developed a number of better and worse ways to calculate or estimate it, however the most dominant these days is the analytic calculus, used in the capital asset

pricing model, CAPM, although it should be noted that in many cases of project assessment the discount rates are chosen subjectively by an analyst using the intra-branch benchmark.

The hereby article presents both approaches, as well as issues and doubts arising from discount estimation in each of the methods.

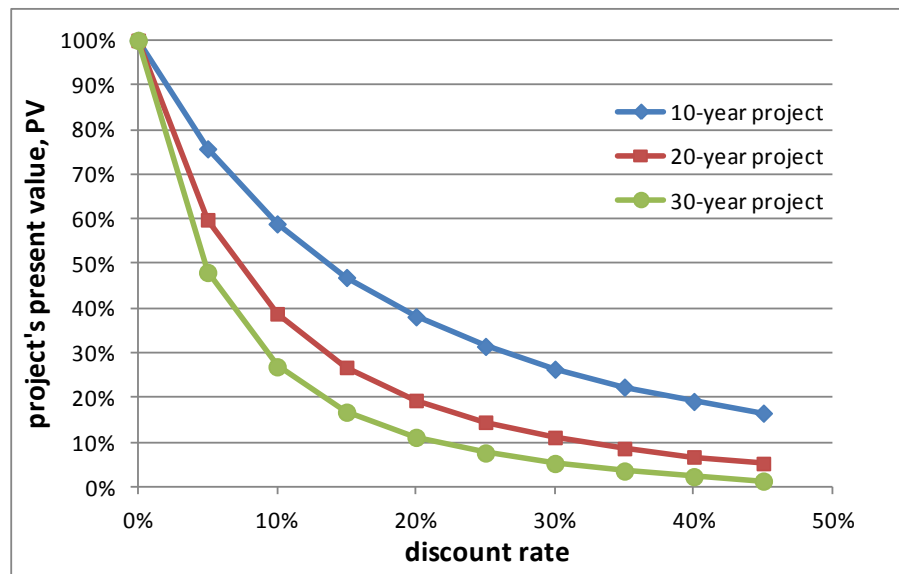


Fig. 1. Influence of discount rate on present value of project

Source: Zamasz K.: Efektywność ekonomiczna przedsiębiorstwa energetycznego w warunkach wprowadzenia rynku mocy. PWN, Warszawa 2015.

2. Discount rate components

As mentioned before, the level of discount rates reflects the scope of risk associated with a given project. In cases when a project is financed with equity and external funds, the discount rate used for calculations is the weighted average of the cost of equity and cost of debt, according to the following formula:

$$WACC = r_e u_e + r_d u_d \quad (1)$$

wherein:

u_e, u_d – the proportions of equity and debt within the capital expenditures,

r_e – cost of equity (RADR),

r_d – cost of debt.

In literature, such a rate is called the pre-tax rate. Since interest expenses are deductible, which in turn reduces the tax base – in finance the more common formula is after-tax WACC:

$$WACC = r_e u_e + r_d (1 - tax) u_d \quad (2)$$

wherein:

tax – income tax rate;

$(1 - tax)$ – the tax shield.

DCF calculations of projects with the use of both discount rates presented above – while maintaining the same cash flow assumptions (discounting of pre-tax cash flows at a pre-tax discount rate or discounting post-tax cash flows at an after-tax rate) should both give the same results¹, however, some researchers² prefer to carry out calculations in accordance with the second mode – the ‘after-tax’ model).

The discount factors may be presented in nominal (stated) and real rates (adjusted for inflation) stating the reference or base year. The relationship between the nominal and real rates is expressed in the Fisher formula:

$$1 + N = (1 + r)(1 + i) \quad (3)$$

wherein:

N – nominal rate,

r – real rate,

i – inflation rate.

The discount rate components have been presented in the example of cost of equity (RADR). The RADR coefficient includes two basic percentages (Fig. 2):

- 1) risk-free rate,
- 2) specific risk segment.

Specific risk range includes mostly portions of risk associated with revenues, operating costs, investment expenditures and project lifetime; among them the largest percentage share is attributed to – due to the price volatility – revenues. Another component of the discount rate may be the inflation contribution – in cases of real-value project calculations, it is being eliminated. Should the investors decide to assess any foreign projects, the discount rate is increased by the risk component related to the risk of investing in a given country (country risk).

One of the methods of discount level estimation relating to the country risk is based on the reports prepared by international rating agencies (S&P, Moody’s, Fitch-IBCA etc.).

¹ Jindra J., Voetmann T.: Discussion of the Pre- and Post-Tax Discount Rates and Cash Flows: A Technical Note. “The Journal of Applied Research in Accounting and Finance”, Vol. 5, Iss. 1, 2010; Hall M.: Pre- and Post-Tax Discount Rates. “The Journal of Applied Research in Accounting and Finance”, Vol. 5, Iss. 2, 2010.

² Davis K.: Why Pre-Tax Discount Rates Should be Avoided. “The Journal of Applied Research in Accounting and Finance”, Vol. 5, Iss. 2, 2010.

Such reports use letter designations, number designations or letter-number rating designations and are developed based on the observation and analysis of several key variables such as:

- the level of debt,
- debt repayment indicators,
- current account balances,
- economic policy and political stability.

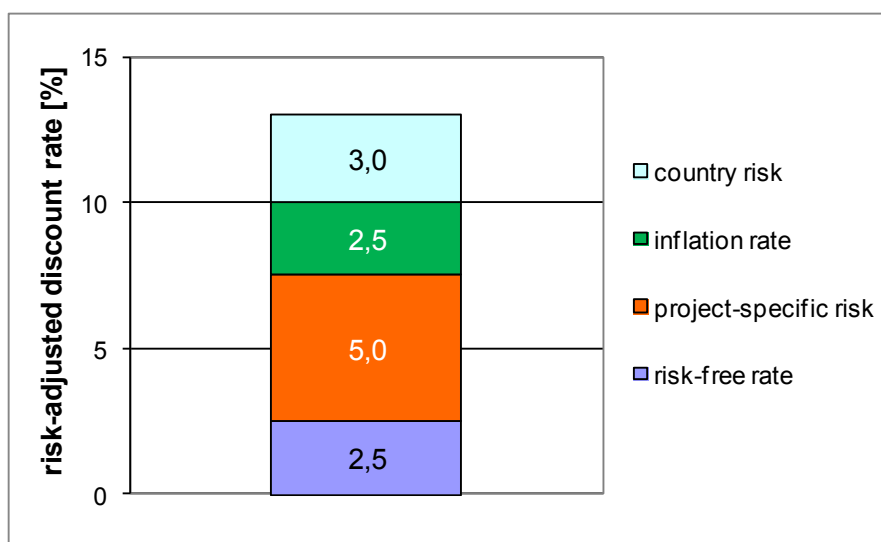


Fig. 2. Components of nominal risk-adjusted discount rate – an example

Source: Zamasz K.: *Efektywność ekonomiczna przedsiębiorstwa energetycznego w warunkach wprowadzenia rynku mocy*. PWN, Warszawa 2015.

The ratings of national investment risk for Poland and neighbouring countries (as of November 2016), including the risk premium, have been presented in table 1.

Table 1

International ratings and the country investment risk bonus for Poland (November 2016)

Country	Moody's rating	Country risk premium
Germany	Aaa	0.00%
Czech Rep.	A1	1.09%
Poland	A2	1.31%
Slovakia	A2	1.31%
Lithuania	A3	1.85%
Russian Fed.	Ba1	3.86%
Belarus	Caa1	11.58%
Ukraine	Caa3	15.44%

Source: Damodaran A.: *Damodaran Online – Data, 2016*, <http://pages.stern.nyu.edu/~adamodar>.

3. Discount rate estimation

3.1. Estimating the cost of equity based on cross-branch surveying

The search for ‘twin’ project is one of the most common approaches in the process of finding the proper discount rate. Hence it is vital for the process that the analyst should have thorough knowledge of similar projects and evaluating their viability. Such experience is not to be underestimated, mainly because – for example – in energy sector projects the ratios may vary over a wide range – from 6 to 15%³ and even more.

It should be emphasized that the ad hoc choice of discount rate representing the cost of equity (RADR) is not preferred when it comes to the energy industry – such a way of determining discount rates may seem controversial due to the wide range of subjective factors. This has certain consequences: for instance, according to the analyses carried out by the Association for Financial Professionals⁴ such way of discount rate selection is only used by ~10% of surveyed companies. The vast majority of companies use the capital asset pricing model (CAPM).

3.2. RADR calculation in the capital asset pricing model

The only analytical method of determining the cost of equity, widely recognized and accepted, is the capital asset pricing model. This method – which has been confirmed by a survey⁵ – is currently being widely used in the energy sector, as well as by banks and other institutions. It should be noted, however, that the condition for an effective application of the capital asset pricing model is to have an ample amount of data and information allowing for the precise application of its algorithms.

CAPM in an equilibrium model which allows for the evaluation of the scale of risk systematically associated with a business activity – it illustrates the relationship between this risk (also referred to as market risk or undiversifiable risk) and the expected rate of return. An important element of the CAPM model is to determine the relation between the rate of return on an individual security and the level of risk. Such a relation in micro scale is defined by means of a linear function referred to as the security market line, SML:

³ Steinbach J., Staniaszek D.: Discount Rates in Energy System Analysis. Discussion Paper, BPIE, Fraunhofer ISI, 2015.

⁴ Association for Financial Professionals: Current Trends in Estimating and Applying the Cost of Capital – Report of Survey Results. AFP, March 2011.

⁵ KPMG: Australian Valuation Practices Survey 2015, kpmg.com.au.

$$E(r_s) = [E(r_m) - r_f]\beta_s + r_f \quad (4)$$

wherein:

$E(*)$ – expected value,

r_m – return from entire market,

r_s – return on shares s ,

r_f – return on risk-free asset,

β_s – beta coefficient for shares s (equal to the ratio of covariance between the variables r_s and r_m and the variance of the random variable r_m).

According to this model, the expected rate of return on shares s is composed of the risk-free component r_f as well as the premium for the risk related to such assets, being a product of the market risk premium $E(r_m) - r_f$ and the beta coefficient. The last is a measure of systematic risk. The level of beta indicates the degree of price volatility of a security in relation to the fluctuations in prices of the entire market. The β_s factor for the s asset can be therefore calculated by dividing the covariance the security's return and the market return by the variance of the market return over a specified period.

According to the portfolio theory the higher beta value, the higher the risk related to given assets. The market beta equals 1; if the ratio for a given asset is >1 , the return rate on the instrument will be more prone to change than the market return rate, whereas in the reverse situation ($\beta < 1$) the asset return rate will be less volatile than the entire-market return rate.

β as a risk coefficient calculated from the historical rate changes in relation to market changes (so called levered beta (β_L)), does not refer to the capital structure. Interestingly, from the investor's point of view, is removing the impact of debt from beta. Such modified coefficient is called unlevered beta (β_{UL}). The unlevered beta tells us how much of the observed share risk for a given company is specific (directly related to this company – by means of its business model, manner of management, assets and market connections.) The formula presenting the relationship between those two types of beta coefficient is as follows:

$$\beta_L = \beta_{UL} \left[1 + (1 - tax) \frac{D}{E} \right] \quad (5)$$

wherein:

β_L – levered beta,

β_{UL} – unlevered beta,

tax – income tax,

D – loan amount,

E – own equity.

Table 2 presents the average beta coefficients as well as nominal and real equity cost rates, calculated for companies of the energy industry in the United States, in the years 2001-2015.

Having analysed the presented data, it is easy to see that the shares of the energy sector companies are much more volatile than the market itself. The average beta in the industry for the period of 2001-2015 in the USA is 1.45; Using the formula (3) and taking into account risk-free rates – the nominal average cost of equity for the branch was calculated and estimated at 10.87%. Recalculating it gives us the real rate of 8.52%.

Table 2

Beta coefficients and own equity costs for the power industry
in the United States in the years 2001-2015

Year	Number of firms	Beta coefficient	Nominal RADR	Real RADR
2015	73	0.80	7.05%	6.95%
2014	82	0.83	6.94%	5.25%
2013	106	0.68	6.43%	4.86%
2012	101	1.35	9.61%	7.35%
2011	93	1.35	10.03%	6.62%
2010	67	1.34	9.64%	7.91%
2009	77	1.23	9.20%	9.64%
2008	65	1.65	12.11%	8.00%
2007	57	1.92	14.11%	11.00%
2006	41	2.39	16.42%	12.81%
2005	25	2.23	15.10%	11.32%
2004	24	1.56	11.76%	8.82%
2003	19	1.45	11.23%	8.73%
2002	23	1.66	11.32%	9.57%
2001	19	1.29	12.07%	9.02%
Average		1.45	10.87%	8.52%

Source: Own study based on source: Damodaran A.: Damodaran Online – Data, 2016, <http://pages.stern.nyu.edu/~adamodar>.

An interesting phenomenon is the significant decrease, in the years 2013-2015, of the beta coefficient in the USA – below 1. In 2013 the coefficient for the industry was at an average of 0.68 (RADR (real) – 4.86%), and in 2015 – 0.8 (with the cost of equity (real) of 6.95%). That means that in the years mentioned above, the return on investments in power sector companies' shares were less volatile than the market average (i.e. they were safer). Those results are in contrast with the data relating to the European market – where the beta coefficient for the European energy market in 2015 (76 companies) was similar to the market beta (0.95), which means that the average equity cost of the sector is about 9.1%, while in the case of the renewable energy sector (48 European companies), the beta coefficient in the same year was 1.24, which corresponds to the nominal equity cost of 11.18%⁶.

3.3. Hurdle rates for electricity generation technologies

It should be emphasized that in the energy sector – due to the common funding of projects with foreign funds (debt) – analysts usually use the weighted average cost of capital (WACC).

⁶ Ibidem.

The expectations of entrepreneurs (and investors) are represented by the co-called hurdle rate, which is any minimum acceptable rate of return (MARR) required by the shareholders in the process of project assessment, regardless of the estimation methodology. The most common approach of discount rate estimation in the energy sector has been illustrated in Fig. 3. The chart shows all important factors determining the choice of proper rate, in relation to:

- systematic risk (evaluation of the cost of equity, RADR),
- non-systematic risk (along with others), which formulate the hurdle rate, differing from the estimates derived from CAPM.

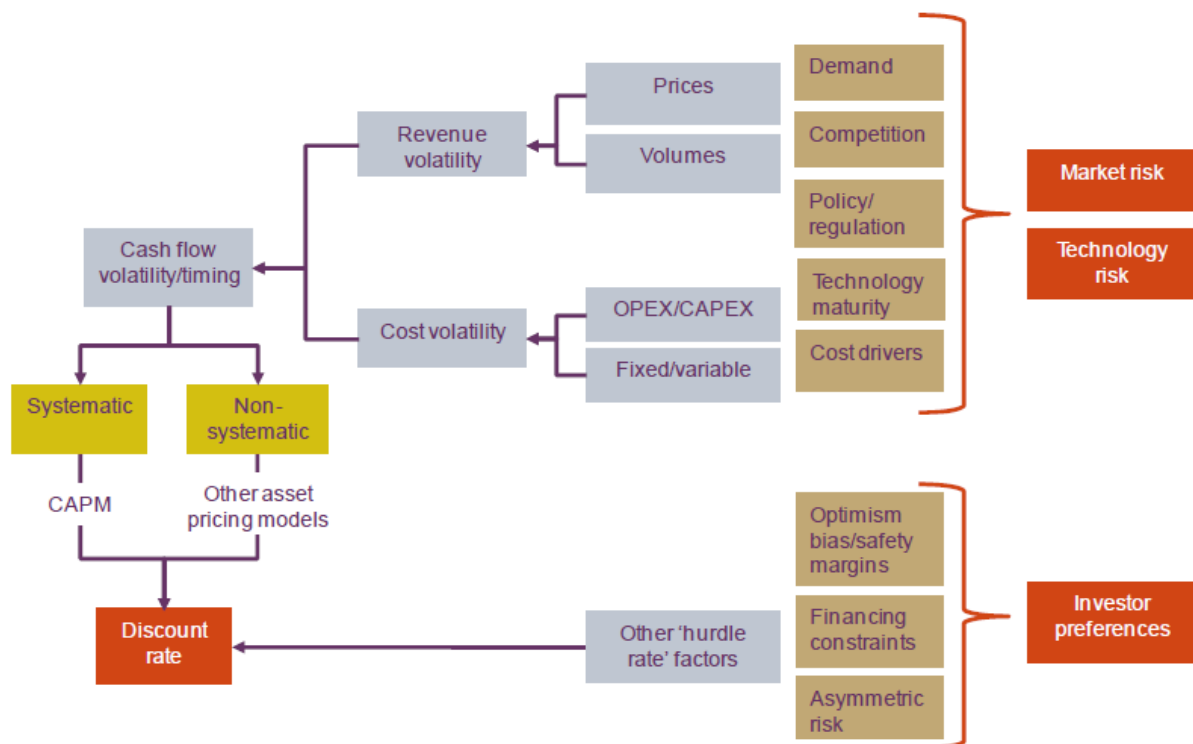


Fig. 3. Determinants of investor hurdle rates

Source: Oxera: Discount Rates for Low-Carbon and Renewable Generation Technologies, prepared for the Committee on Climate Change, April 2011.

The practice of the energy sector confirms that the discount rate obtained by means of the capital asset pricing model CAPM is subjectively adjusted⁷ towards the hurdle rate directly related to the weighted average cost of capital. Figure 4 presents the hurdle rate required for the planned electricity generation projects in accordance with the used technology. It is clear that the discount rate increases together with the investment risk – hence: for gas-steam CCGT (low-risk) energy projects, the most common (real, pre-tax) discount rate is 7.5%, whereas in wave induction power plants (high risk) the discount rate is about 15.5%⁸. Detailed

⁷ Khatib H.: The Discount Rate – A Tool for Managing Risk in Energy Investments. International Association for Energy Economics, 2014.

⁸ Oxera: Discount Rates for Low-Carbon and Renewable Generation Technologies, prepared for the Committee on Climate Change, April 2011.

information on the discount rates in the energy sector has been presented in Table 3. The table depicts ranges of hurdle rates for the most important low-carbon electricity generation technologies, estimated by a number of major companies and institutions: Oxera, Arup, RedPoint, DECC and NERA. The values estimated by the latter relate to the projects in the preliminary assessment stage, performed prior to a pre-feasibility study. The table shows real values before taxation (pre-tax, real) recalculated from nominal values and adjusted for inflation of 2%. It is clear that depending on the entity performing the assessment the estimation results differ quite considerably.

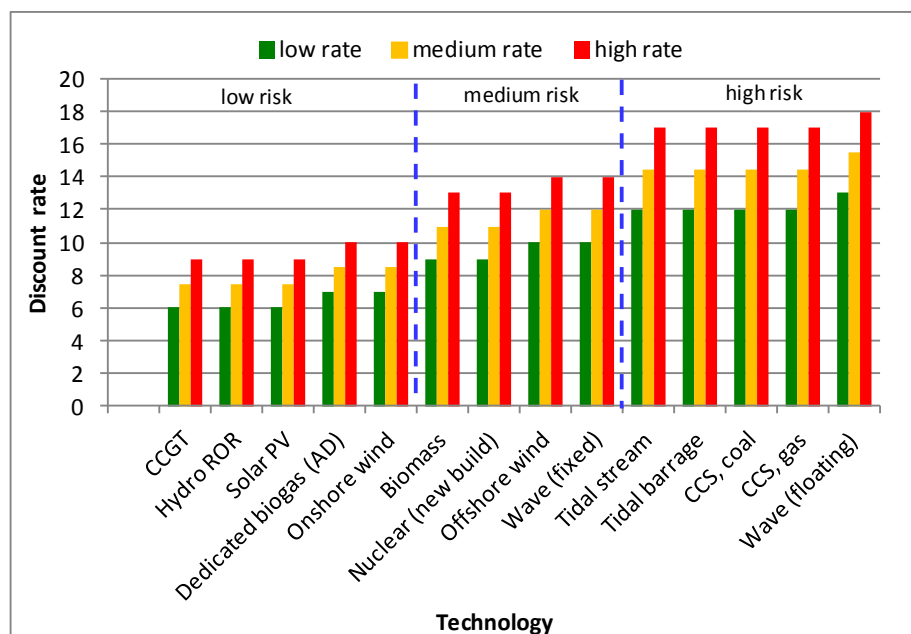


Fig. 4. Discount rate ranges (pre-tax, real) across different risk and electricity generation (low carbon) Technologies

Source: Own study based on Oxera: Discount Rates for Low-Carbon and Renewable Generation Technologies, prepared for the Committee on Climate Change, April 2011.

In 2015 NERA carried out an intra-branch survey which allowed it to modify its existing ratings: the largest differences related to the Gas CCGT/OCGT, where the research shows an almost 3-percent in-minus difference of the average (7%) compared with the reference level by NERA (9.8%); the average rate obtained in the survey is similar to that estimated by Oxera and DECC (7.5%). An interesting case relates to the Coal CCS technology, where the survey has determined the average hurdle coefficient (11%) at a level much below than NERA's reference point (12.8%) as well as Oxera's (14.5%) and DECC's (13.5%) estimations. This proves that the sector is less afraid of the technology-related risks than the consulting companies.

Table 3

Hurdle rate estimates for low carbon technologies

Technology	OXERA 2011	ARUP	RedPoint	DECC 2013	NERA 2015
Solar PV	7.50%	7.80%		5.30%	8.00%
Biomass conversion	11.00%	14.40%	13.20%	10.90%	11.60%
Biomass CHP				13.60%	13.70%
Onshore Wind	8.50%	10.60%	8.10%	7.10%	8.20%
Offshore Wind	12.00%	11.30%	11.90%	9.90%	10.40%
Waste (ACT Adv./AD)	8.50%	15.10%	13.20%	10.00%	11.70%
Waste (landfill, EfW)		13.50%	10.60%	5.70%	8.90%
Hydro	7.50%		8.10%	5.80%	8.40%
Wave	13.80%		13.20%	11.00%	11.50%
Tidal Stream (deep)	14.50%		13.20%	12.90%	12.80%
Geothermal		22.70%		22.00%	10.90%
Gas CCGT/OCGT	7.50%			7.50%	9.80%
Gas – retrofit investments					9.70%
Coal – retrofit investments					10.20%
Nuclear	11.00%			9.50%	11.70%
CCS (coal)	14.50%			13.50%	12.90%
CCS (gas)	14.50%			13.80%	12.80%

Source: NERA Economic Consulting: Electricity Generation Costs and Hurdle Rates. Lot 1: Hurdle Rates update for Generation Technologies. Prepared for the Department of Energy and Climate Change (DECC), July 2015, www.nera.com.

4. Conclusions

The project-specific discount rate is a parameter that reflects the risk related to the project fairly well. One should bear in mind that despite the use of validated analytical methods (CAPM), a subjective factor (analyst's experience) also plays a vital role in the estimation process. This factor is difficult to eliminate due to the fact that the data obtained by means of CAPM analysis is usually:

- based on historical data,
- cost of capital of a company's (often operating in various sectors) and rarely a discount rate specific to project undertaken.

The discount rate levels estimated by consulting companies may be, either way, an important point of reference (useful in cases of various project comparisons). However, experienced analysts having available reports and literature may correct the reference rates – both up or down. Of course, this leaves room for yet another error, one resulting from personality, subjective views or the analyst's opinions: some estimations may be overly optimistic, while others to the contrary – too pessimistic.

It should be emphasized that the discount rates should apply to the future – although, in fact, they are estimated based on the current (and/or historical) data. The most doubtful issue being the need for forecasting itself – the analysis' quality and results depend largely on the

their skills and experience. Figure 5 shows the estimation methodology for future hurdle rates in low-carbon technologies. The methodology should consider the changes in risk perception for such technologies over time, together with the changes in risk-free rates, scopes of financing and changes within various development scenarios.

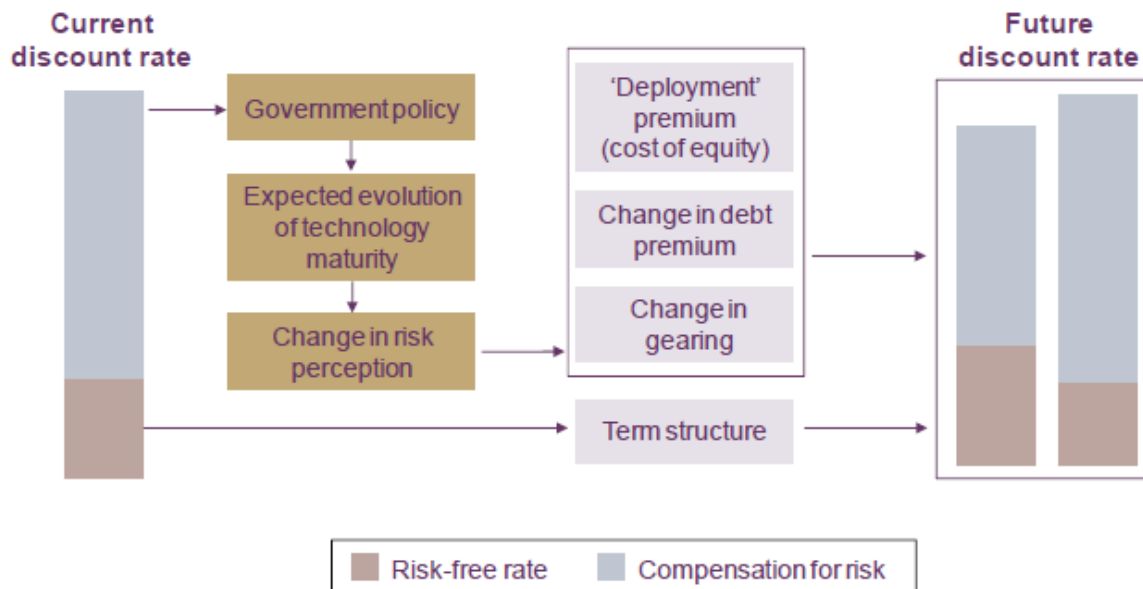


Fig. 5. Evaluation of future discount rates for renewable and low-carbon technologies

Source: Oxera: Discount Rates for Low-Carbon and Renewable Generation Technologies, prepared for the Committee on Climate Change, April 2011.

The need to determine the discount rates for future conditions also applies to the CAPM model. Beta coefficients are derived from historical data regression analyses – and their values fluctuate along with the market changes which, consequently, lead to the continuous change in the values of individual projects. On the other hand – for example – such practice has been known in conventional power industry for years – the processes are well-known and repeatable, which adds a significant amount of credibility to the historical data. Hence, the determination of a reasonable amount of discount for such projects proves to be not so difficult after all. That is why many analysts present the discount rates as intervals from-to, which seems a rational practice.

Yet, the most important objection to the CAPM model is related – as mentioned before – to the instance of beta coefficients ‘measuring’ company (sector) risks, while the discount rates based on them should rather be dedicated to the investment projects. The problem escalates when a company operates in various sectors, taking up different projects at different risk levels. Unfortunately, the practice is such that the companies use the same capital cost calculated by means of the CAPM model for all their projects. That is also the reason why, at certain stages, intervention of an experienced analyst is required – to make, sadly subjective, corrections.

The lack of a stability attribute of discount rates is not only connected with the changes in beta coefficients, but also with the uncertainty of the project realization dispersing overtime (the learning effect). At the pre-implementation stage, a lack of information implies greater risk. During the transition to a more detailed project, at the stage of feasibility study, followed by construction, start-up and carrying out of all production operations, the uncertainty related to the risk components is being reduced. The logical inference being that after the construction of a power plant, investment risk is reduced to zero, since the capital was fully utilized and the costs are known. The uncertainty related to the operating costs drops drastically after the first year of production. It can be said that with the passage of time the reduction of the risk factors associated with income and the prospect of a termination of exploitation will be relatively small – mainly due to the price volatility and the project operating conditions. That is why some of the specialists suggest using, for the sake of the DCF analysis, of a degressive coefficient updating cash flow values and including different rates for different phases of the project. Unfortunately, no mathematical model of such a procedure has been developed so far.

Research on the problem of selection of discount rates adequate for risk has continued for a long time, nonetheless, no comprehensive solution – satisfactory to both theoreticians and practitioners – has been found. Therefore, some of these studies are moving towards giving up the need to select the discount rate (real options valuation, ROV) – though, also in this area, research has not been successful⁹.

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