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Assessment of a Social Discount Rate and Financial Hurdle Rates for Energy System modelling in Viet Nam

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Keywords: Viet Nam, Energy Planning, Discount Rates, Hurdle Rates, Cost of Capital, Clean Energy

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Abstract

Viet Nam's sustained economic development is driving increasing demand for electricity with generation capacity predicted to nearly double over the next decade. With the majority of economic hydropower resources utilised, delays in coal power pipelines, and increasing energy insecurity, Viet Nam has pivoted its electricity sector development plans to further prioritize the deployment of wind and solar generation. A clean energy transition such as this can deliver multiple social and economic benefits related to cost reductions, improved energy security, and public health.

This working paper was prepared to support least-cost energy sector planning in Viet Nam particularly for the upcoming Viet Nam Energy Outlook 2021 (VEO21) being prepared in partnership between Viet Nam's Ministry of Industry and Trade (MOIT) and the Danish Energy Agency (DEA). This working paper discusses the use of discounting in energy models and the potential impact discount rate selection may have on a model's cost-optimised technology selections. The paper also analyses the clean energy finance environment in Viet Nam to identify opportunities for policy levers to reduce the prevailing cost of capital and how these cost implications can be tested in the VEO21 modelling exercise.

The main outputs of this working paper are two sets of model inputs, an estimate for an appropriate social discount rate and secondly a set of high and low financial hurdle rates for renewable energy technologies for use in sensitivity or scenario analysis.

Keywords: Viet Nam, Energy Planning, Discount Rates, Hurdle Rates, Cost of Capital, Clean Energy

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Résumé

Le développement économique soutenu du Viet Nam entraîne une hausse de sa demande d'électricité qui, selon les prévisions, le conduira à presque doubler sa puissance installée au cours de la prochaine décennie. La majorité de ses ressources hydroélectriques économiquement rentables étant déjà exploitées, sa filière à charbon subissant des retards, et l'insécurité énergétique s'aggravant, le Viet Nam réoriente ses projets de développement du secteur de la production d'électricité pour donner plus ample priorité au déploiement de centrales éoliennes et solaires. Une telle transition vers les énergies propres peut offrir de multiples avantages sociaux et économiques, en lien avec la réduction des coûts, le renforcement de la sécurité énergétique, et la santé publique.

Ce document de travail a été préparé pour soutenir une planification au moindre coût du secteur de l'électricité au Viet Nam, en particulier dans l'optique de la parution de l'ouvrage Viet Nam Energy Outlook 2021 (VEO21), élaboré en partenariat avec le ministère vietnamien de l'Industrie et du Commerce et l'Agence danoise de l'énergie. Il examine l'utilisation du taux d'amortissement dans les modèles énergétiques et l'impact que le choix d'un certain taux peut avoir sur les choix technologiques optimisées en termes de coûts dans le modèle. Il analyse le contexte de financement des énergies propres au Viet Nam, afin de recenser les leviers d'action qui pourraient être actionnés pour réduire le coût du capital qui prédomine, ainsi que les moyens de tester ces conséquences en termes de coût dans l'exercice de modélisation VEO21.

Les principaux produits de ce document de travail sont, d'une part, deux ensembles de données d'entrée pour le modèle et une estimation d'un taux d'amortissement approprié au plan social et, d'autre part, un ensemble de valeurs faibles et élevées des taux de rendement minimum applicables aux énergies renouvelables, qui peuvent être utilisés dans des analyses de sensibilité ou de scénario.

Mots-clés : Viet Nam, Planification énergétique, Taux d'amortissement, Taux de rendement minimum, Coût du capital, Énergie propre

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Abbreviations and Acronyms

BAU: Business as Usual

CAPM: Capital Asset Pricing Model

CEFIM: Clean Energy Finance and Investment Mobilisation Programme

DR: Discount Rate

DEA: Danish Energy Agency

EREA: Electricity and Renewable Energy Authority

ETSAP: Energy Technology Systems Analysis Program

EU: European Union

IEA: International Energy Agency

IPCC: Independent Panel on Climate Change

LCOE: Levelised cost of energy

MOIT: Ministry of Industry and Trade

PPA: Power Purchase Agreement

PPP: Public Private Partnership

PV: Photovoltaic

SDR: Social Discount Rate

SRTP: Social Rate of Time Preference

VEO: Viet Nam Energy Outlook

VND: Vietnamese Dong

WACC: Weighted Average Cost of Capital

Executive Summary

To support power sector planning in Viet Nam the Ministry of Industry and Trade (MOIT) is working in partnership with the Danish Energy Agency (DEA) on the next edition of the Viet Nam Energy Outlook Report for 2021 (VEO21). The report will present modelling results of cost-optimised power and energy sector development scenarios consistent with Viet Nam's policy targets. This report has been prepared to support the selection of an appropriate social discount rate for the model through review of best practice in this area. The report also estimates low and high cost of capital scenarios for renewable energy technologies for use in sensitivity or scenario analysis. The findings of the report are based on literature reviews and interviews with sector stakeholders including local and international financial institutions and renewable energy project developers active in Viet Nam.

The VEO21 is utilising the TIMES model, a cost optimising energy system model developed to facilitate sector planning by the IEA's Energy Technology Systems Analysis Program (ETSAP). TIMES requires the specification of a social discount rate that discounts system costs back from when they occur to a present value at a base year for use in a cost optimisation calculation that returns a 'social optimum' technology deployment. Discount rate selection is a controversial subject as it involves making judgements on the allocation of costs and benefits between present and future generations. The higher the discount rate, the less weighting is given to future costs. An inappropriately high discount rate therefore understate costs that occur in the future. In energy sector modelling this leads to a systematic undervaluing of non-fuel-intensive, and higher-capital-intensive investment options, such as energy efficiency and renewable generation. A social discount rate for Viet Nam has been estimated using the Social Rate of Time Preference method between the range of 6 to 8% with a preference for the lower bound in line with best practice employed by the Intergovernmental Panel on Climate Change. For the model to adequately return a socially optimum outcome requires the inclusion, to the greatest extent possible, of all related external costs that could lead to a societal loss in welfare. In the case of energy system models, this would include the external costs of local air pollution such as particulate matter and other pollutants from fossil fuel combustion that cause environmental damages and health impacts. It would also require the inclusion of the environmental costs of greenhouse gas emissions. Such assessments are often ignored in energy system models at the detriment of cleaner, renewable generation alternatives.

Financial hurdle rates, defined as an estimation of the prevailing weighted average cost of capital (WACC), can be applied in the TIMES model to undertake ex-ante policy analysis where a policy choice may impact the revenue or cost positions of a technology or sector (Steffen, 2020[1]). Based on interviews with a domestic bank, foreign bank, and renewable project developers, the highest potential for WACC reduction in Viet Nam's renewable energy market is identified as the mitigation of curtailment risk through a revision of the standardised power purchase agreement for independent power producers. Financial hurdle rates have been estimated for renewable energy technologies under a high and low financing cost policy scenario linked to this revision (10% high rate and 7.5% low rate). These financial hurdle rate estimates can be applied in scenario or sensitivity analysis to support the government understand the benefits of mitigating curtailment risk through this regulatory action.

1 Specifying a Social Discount Rate

This section provides a background discussion on the use of social discount rates and financial hurdle rates in energy system modelling and the influence they wield on cost-optimised technology selections, particularly between renewable vs. fossil fuel generation. A country-specific social discount rate is estimated for Viet Nam using the Social Rate of Time Preference (SRTP) method.

Background to Discount Rates and Hurdle Rates in Energy System Modelling

The TIMES modelling framework (Integrated MARKAL-EFOM) will be utilised for the VEO 2021. TIMES is a multi-sectoral optimisation model that calculates a least-cost energy system configuration that meets projected annual energy end-use demand while adhering to limits on resources and/or policy constraints placed on the model. The total discounted system cost (the TIMES objective function that is minimised) encompasses costs arising from the supply (production and import/export) and consumption of energy including fuel expenditures, investments in power plants, infrastructure, purchases of demand devices, and fixed/variable operating and maintenance costs associated with all technologies (DEA and EREA, 2019[2]). The model forecasts these future cost streams and discounts them into a present value for comparison at a baseline year. This process works iteratively to produce a technology selection that is cost-optimised. The process of calculating the present value through discounting reflects the idea that there is a price associated with the date at which benefits and costs occur. Typically, it is assumed that the price of a unit of consumption in the future is lower than the price of a unit of consumption today. So when one adds up the net benefits of a particular investment over time, future costs and benefits receive less weighting (a lower price) than present ones (OECD, 2018[3]).

There are broadly two approaches for discounting:

An ethical, or prescriptive approach based on what rates of discount should be applied to inform a socially optimal outcome. This approach looks to maximize social welfare across time and derive a socially optimal pathway. This approach uses a **social discount rate** that is applied across all sectors and technologies. The social discount rate represents the sum of the rate of pure time-preference and the rate of increase of welfare derived from expected higher per capita incomes in the future. A social discount rate can be thought of as the rate at which consumption would have to increase into the future to keep social welfare constant given a unit reduction in consumption today.

A descriptive approach based on what rates of discount investors apply in real world investment decision making. Such a discount rate would reflect the cost of financing calculated as a prevailing weighted average cost of capital (WACC) for a technology or sector. In this note, we refer to this form as a **financial hurdle rate.** An additional treatment of discounting under this descriptive approach is one that adds a premium to the financial hurdle rate that represents irrational, behavioural barriers to investment that explain the sub-optimal deployment of certain technologies witnessed in global markets. Private decision making for energy efficiency investment is particularly noted for these kinds of non-market barriers. In this note, we refer to this form of discount rate as a **behavioural hurdle rate**.

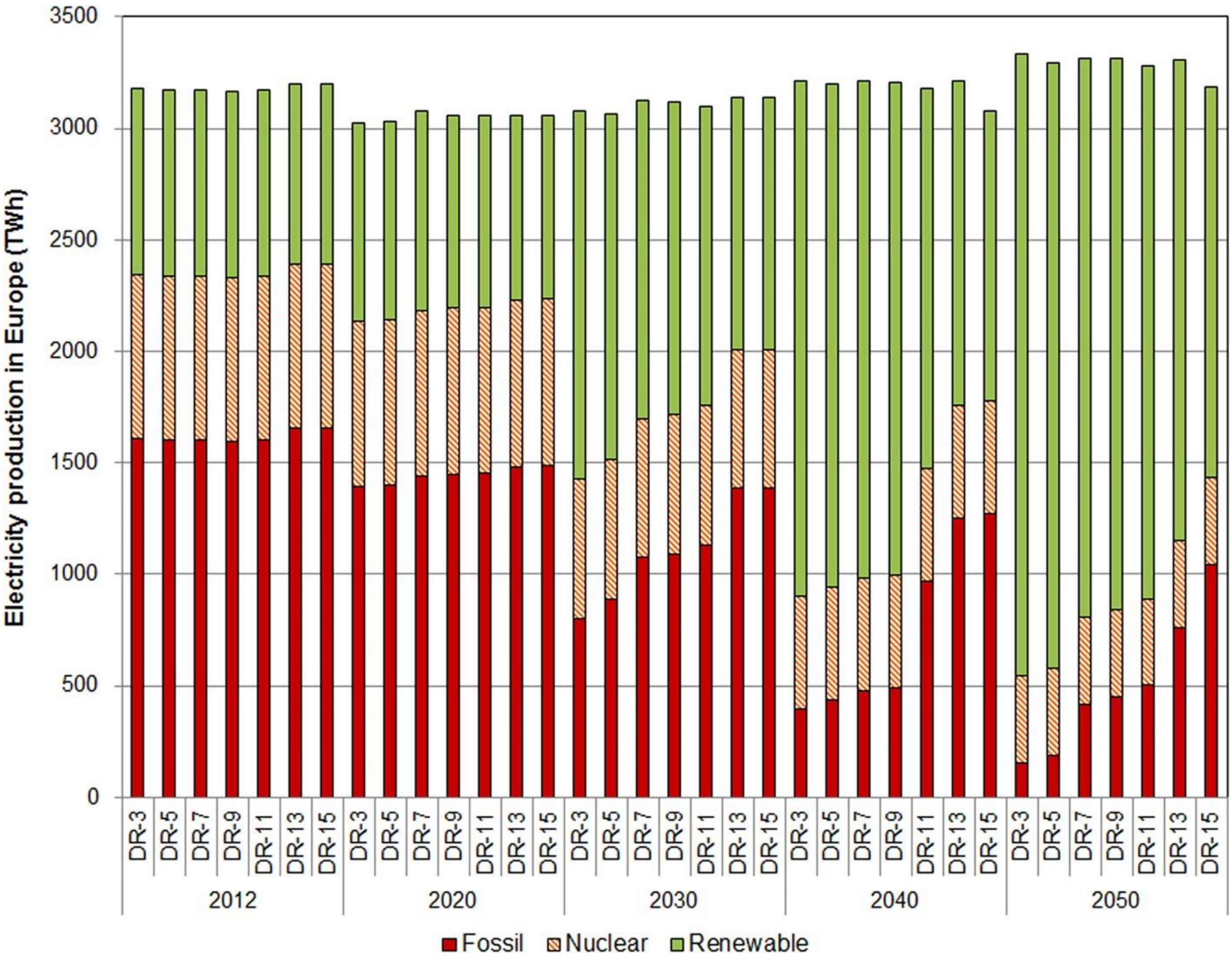
Discount rate selection is a controversial subject as it involves making judgements on the allocation of costs and benefits between present and future generations. The higher the discount rate, the less weighting is given to future costs. An inappropriately high discount rate would therefore understate costs that occur in the future. In energy sector modelling this leads to a systematic undervaluing of non-fuel-intensive, and higher-capital-intensive investment options, such as energy efficiency and renewable generation. These technologies have high upfront costs and low operational costs. Their total lifecycle costs are therefore discounted less compared to fossil fuel generators that have a greater proportion of total cost occurring over their project lifetime in the form of fuel costs.

Figure 1.1 demonstrates such an effect with the results of a sensitivity analysis using a TIMES model for the European Union (EU) energy system (JRC-EU TIMES). Different generation technologies were grouped into three categories: fossil fuel, nuclear, and renewable, and varying discount rates between 3% to 15% were applied to several model runs. The technology mix selected by the model at different discount rates clearly shows the degree of influence the discount rate plays, particularly over the long run. Given the high degree of influence the discount rate wields on system planning, the selection of a discount rate should be clearly justified and matched to local context. Ideally, the selection should also be centrally managed to ensure consistency across central and sectoral models and to ensure political accountability.

A study of practices in Sweden, for example, found discount rate setting and utilisation was "uncoordinated, insufficiently justified, insufficiently transparent, and therefore not politically accountable" (Hansson et al., 2016[4]).

Another important aspect of discount rate selection is to ensure alignment of the approach with the modelling objectives and the nature of the policy questions that are to be informed. The social discount rate that maximizes social welfare over time (the social discount rate) will return a socially optimum technology selection for which public incentive structures or sector master plans should be designed to achieve. However, the use of a social discount rate does not mimic the investment behaviour of firms or individuals that operate in real world conditions. Applying a financial hurdle rate as a discount rate answers a different type of question; it primarily provides insights into what actions should be taken by private actors to optimize their profits rather than what the goal should be to maximize social welfare. Appropriate applications for using the financial hurdle rate in this way includes the projection of clean energy deployment pathways under real world investment conditions and the ex-ante evaluation of policy interventions that affect the revenue or cost position of different technologies (Steffen, 2020[1]). Applying a behavioural hurdle rate goes one step further by attempting to factor in non-rational investment decision making.

Figure 1.1. Cost optimised generation mix for Europe with different model discount rates applied



Note: DR = Cost-optimised technology selection with discount rate set to 3%, 5%, 7%, 9%, 11%, 13%, 15%
Source: (García-Gusano et al., 2016[5])

It must be stressed that for any optimisation model to adequately return a socially optimum outcome would require the inclusion, to the greatest extent possible, of all related external costs that could lead to a societal loss in welfare. In the case of energy system models, this would include the external costs of local air pollution such as particulate matter and other pollutants released from fossil fuel combustion that cause environmental damages and adverse health impacts. It would also require the inclusion of the environmental costs of greenhouse gas emissions that also lead to economic costs and reductions in welfare globally. Such assessments are often ignored in energy system models at the detriment of cleaner, renewable generation alternatives.

Discounting in TIMES Energy Models

The TIMES model requires the inputting of a global discount rate which is used to discount all future costs back to the model's base year. The TIMES model also allows the inputting of technology or sector specific hurdle rates. These specific hurdle rates, as has been described above, can be used to represent private financing costs (a financial hurdle rate) or additional behavioural, or other non-market barriers (a behavioural hurdle rate). These specific hurdle rates, as used in the TIMES calculations, cannot be defined as discount rates as they are not used for the discounting of future values into a present value. The specific hurdle rates are instead used in TIMES for uplifting the capital costs in the model by increasing the total capital recovery over the project lifetime. Operation and maintenance costs are unaffected by the inputting of a hurdle rate. This is a valid treatment as an increased cost of finance would only affect capital costs. These increased costs are then discounted back to base year using the global discount rate which can be set to an appropriate social discount rate value. Hurdle rates and a social discount rate therefore both work together in TIMES. As with the social discount rate, specifying hurdle rates should be done with caution as an inappropriately high hurdle rate would further disadvantage renewable energy options over fossil fuel as they have a higher proportion of their total costs as capital cost and therefore would be disproportionately affected. It is also important that the use of hurdle rates should only be considered where it fits with the modelling objectives. IEA ETSAP model guidelines suggest the following:

> "While a technically sound approach to modeling, hurdle rates can be challenging to use in practice because the appropriate values are difficult to estimate, and they introduce an artificial cost into the objective function that can make scenario cost comparisons difficult. So in TIMES what is usually done is to apply hurdle rates to devices that slow their penetration in the Reference scenario to an acceptable level, which may mean keeping them out altogether. Then when doing policy scenarios that are aimed at lowering the barriers to the uptake of such technologies, the hurdle rates can be lowered and their penetration evaluated. To help with this task the TIMES report writer splits out the core investment expenditures (using the global discount rate) and the amount arising due to the higher discount rate. This helps give a sense of the potential costs and benefits of policies that have the potential to lower these hurdle rates." (IEA-ETSAP, 2016[6])

There are therefore two potential uses for hurdle rates in the VEO21 depending on the modelling objective:

- In a reference scenario that aims to simulate real world deployment rates in a business as usual (BAU) scenario. Such a scenario would attempt to answer the question: *How would the energy system evolve if there were no changes to the policy or financing landscape or the prevailing behavioural barriers as they exist today?* In reality, estimating such hurdle rates would be fraught with uncertainty and lead to low levels of predictive power particularly over a long-term period. Given the quickly changing policy landscape and degree of centralised planning in Viet Nam's energy sector such an approach also becomes less valid. There are therefore no clear benefits to calculating a reference scenario in this way compared to the simpler approach of setting exogenous constraints in the model aligned with existing long-term energy sector targets. This is the method previously employed for the VEO19.
- To test the private cost implications of different policy choices in the achievement of generation deployment targets. Such an approach could be taken through a scenario using a low and high financing cost linked to certain, identifiable policy levers. Such analysis could be conducted in two ways, firstly, by constraining the model run to deliver the socially optimum technology selection based only on the social discount rate while also applying in turn the high and low financial hurdle rates. This would mean that the hurdle rates would not inform technology selection but return an estimation of the cost reduction potential of the policy levers that could reduce the cost of financing. The second approach would involve allowing the high and low financial hurdle rates to inform the model's technology selection.

Estimating a Social Discount Rate for Viet Nam

A social discount rate that is appropriate to Viet Nam's economic context should be used in the VEO21 modelling. Given Viet Nam's pace of economic growth a social discount rate for Viet Nam would naturally be set higher than one for developed economies. This is because if consumption were reduced in the present day, a higher amount of future consumption would be required to keep social welfare constant given the higher expectations of future economic growth and increasing wealth. As has been described in the section 'Background to discount rates and hurdle rates in energy system modelling' a higher discount rate leads to lower levels of cleaner investment alternatives selected in a model's cost-optimisation process due to their higher capital intensity. This is problematic as cleaner alternatives also avoid higher levels of future societal costs, which are typically not accounted for. It therefore becomes even more important when applying energy models in an emerging market context to include external costs related to the effects of higher local pollution and greenhouse gas emissions.

There are a number of methods to estimate an appropriate social discount rate but the most common and widely accepted is the Social-Rate of Time Preference (SRTP) method, which is derived from the equation below[1]:

Social Discount Rate = SRTP = $\delta + \mu g$
Where:
δ *= The pure rate of time preference reflecting society's "impatience" and can be considered the rate of decrease in the utility of incremental consumption purely based on consumption occurring in the future*
μ *= Elasticity of marginal utility with respect to consumption, in other terms the declining rate of utility with each additional unit of consumption. As a country gets wealthier each*

[1] For more detailed discussion on methods of discount rate estimation see OECD (2018), "Discounting", in Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris, https://doi.org/10.1787/9789264085169-11-en.

unit of consumption will provide a decreasing amount of utility
g = Expected growth rate of per-capita consumption

Estimation of the applicable social discount rate for Viet Nam is presented in Table 1.1 below:

Table 1.1. Estimate of social discount rate parameters

	Low Estimate	High Estimate	Comments
δ = Rate of pure time preference	0	1.1	This parameter is the most controversial with low levels of consensus among experts on its use and appropriate value. A value higher than 0 factors into the discount rate an estimate for 'impatience' which many feel is not appropriate when considering intertemporal equity. A survey of 200 experts returned an average (mean) estimate of 1.1. However, the modal value was 0 (Drupp et al., 2018[7]). It is noted in the study that these findings go against the IPCC's conclusion that there is "a broad consensus for a zero or near-zero pure rate of time preference" (IPCC, 1995[8]). The Stern Review argues for a very low value of 0.1 if used at all to reflect only the tail risk of societal collapse or human extinction (Stern, 2007[9]).
μ = Elasticity of marginal utility with respect to consumption	1.19	1.3	A survey on life satisfaction as a function of income covering more than 50 countries between 1972 and 2005 returned a highly uniform estimate of μ within a narrow range from 1.19 to 1.3, with an average of 1.26 (Layard, Mayraz and Nickell, 2008[10])
g = Expected growth rate of per-capita consumption	5.3	5.3	Average 1995-2019 of Households and Non-profit Institutions Serving Households Final consumption expenditure per capita growth (annual %) Viet Nam World Development Indicators.
SRTP = δ + μg	**6.3**	**8.0**	Recommended to round to 6 and 8 % with a preference of lower estimate in line with IPCC recommendation of δ.

The SRTP method with parameters as defined above returns a recommended social discount rate for Viet Nam between 6.3% and 8.0%. The higher bound value includes a high rate of pure time preference that many experts would consider inappropriate. The lower bound value, with a treatment for pure time preference more in line with IPCC recommendations, would therefore be preferred.

2 Estimating Financial Hurdle Rates

This section evaluates the prevailing clean energy investment and financing environment and the cost of capital available to renewable energy projects in Viet Nam. Potential drivers for cost of capital reduction are identified and high and low financing costs estimates for use in scenario or sensitivity analysis.

Background to Financial Hurdle Rates and Weighted Average Cost of Capital

As described in the section 'Discounting in TIMES Energy Models' financial hurdle rates can be incorporated into the TIMES energy system model to test the private cost implications of different policy choices in the achievement of generation deployment targets. A financial hurdle rate can be defined as the post-tax Weighted Average Cost of Capital (WACC) calculated with the equation below:

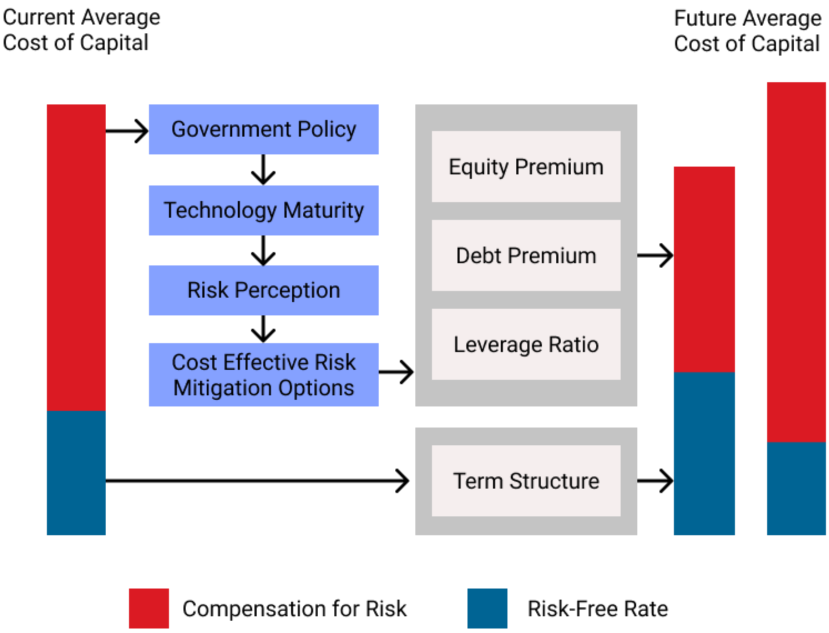
*WACC = Re*E/V+Rd*D/V*(1-Tc)*
Where:
Re = Minimum equity return expectation
E/V = Proportion of total financing that is equity
Rd = Cost of debt
D/V = Proportion of total financing that is debt
Tc = Corporate tax rate

Project cash flow analysis uses WACC as a discount rate to evaluate the return profile of a project or investment. WACC when applied as a financial hurdle rate in the TIMES model is not used for discounting, but for uplifting the level of capital cost of generation (or end-use) assets. This cost uplift represents increased private costs when facing higher financing costs in the market. In cash flow analysis the appropriate WACC parameters: the cost of debt, the equity return expectation, and the leverage ratio (the ratio of debt to equity in the capital structure) are all known inputs specific to a project or corporate entity. In the case of setting financial hurdle rates at the system level one must estimate a WACC value that approximates a market average based on the prevailing financing trends and practices in a country. In reality, this approximation must simplify a complex environment characterised by diverse investor risk preferences, sources of finance, risk mitigation options, policy constraints, etc.

Data on the cost of capital for private transactions in the energy sector are generally not available to policymakers and researchers due to its disperse nature and commercial sensitivity. Studies in this area make use of four different methods to estimate WACC. These include: derivation from available financial market data, replication by modelling public auction outcomes, surveying sectoral experts and elicitation from private parties involved in transactions (Steffen, 2020[1]). A review of existing studies and literature shows there have been no systematic studies of cost of capital in the Viet Nam energy sector. The exception is one study (Kumar, Anisuzaman and Das, 2017[11]) that analysed a number of countries in the region and collected interview data with sectoral experts. This study focused specifically on solar PV financing and estimated a total post tax WACC of 10.4% in 2017 for Viet Nam.

Defining a high and low financing scenario to test the cost implications of policy changes requires the identification of an appropriate policy lever or levers with reasonably predictable impacts on the prevailing WACC. Figure 2.1 shows a simple representation of the drivers behind WACC. Both the debt and equity portions of the financing structure have a risk-free or base-rate portion (shown in blue) that is unaffected by project risk profile or sectoral policy (although they are affected by current and expected macroeconomic conditions). The effect of risk (both real and perceived) on project cash flow certainty is the key driver for equity and debt pricing premium and on the permissible level of leverage a project can achieve. It is this portion that is most effectively reduced through well-designed government policy and regulation, technology maturity, the availability of affordable mitigation options, and through increased transaction experience, training, and access to information that reduces perceived risk.

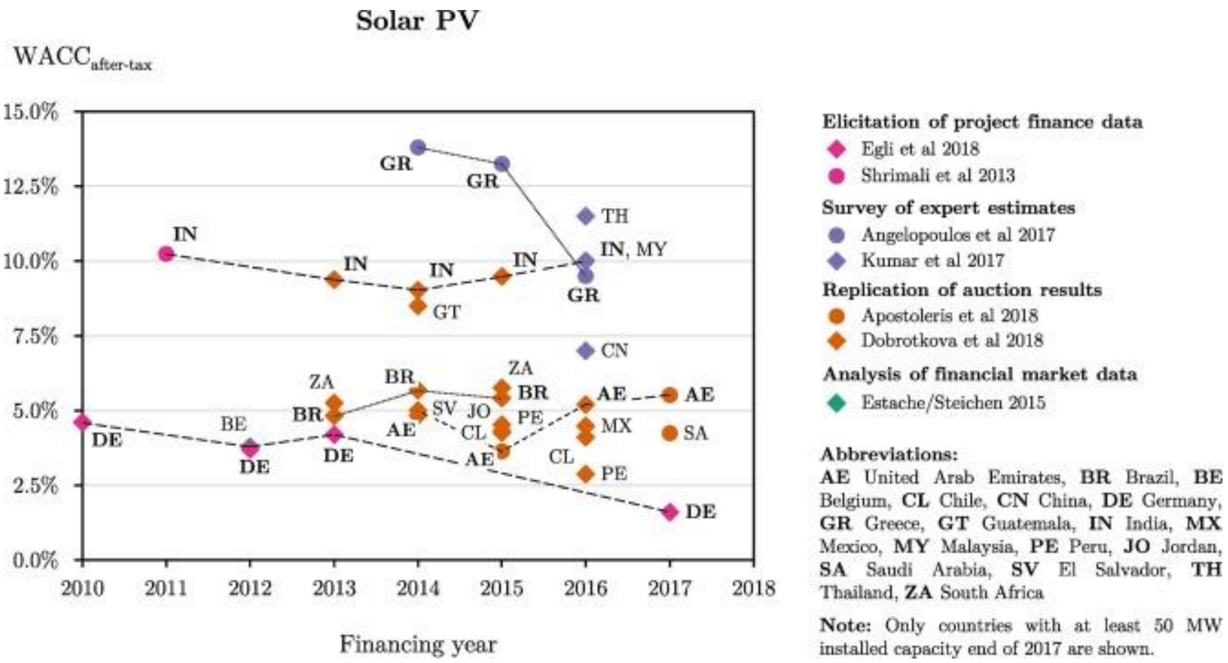
Figure 2.1. Drivers of cost of capital reduction

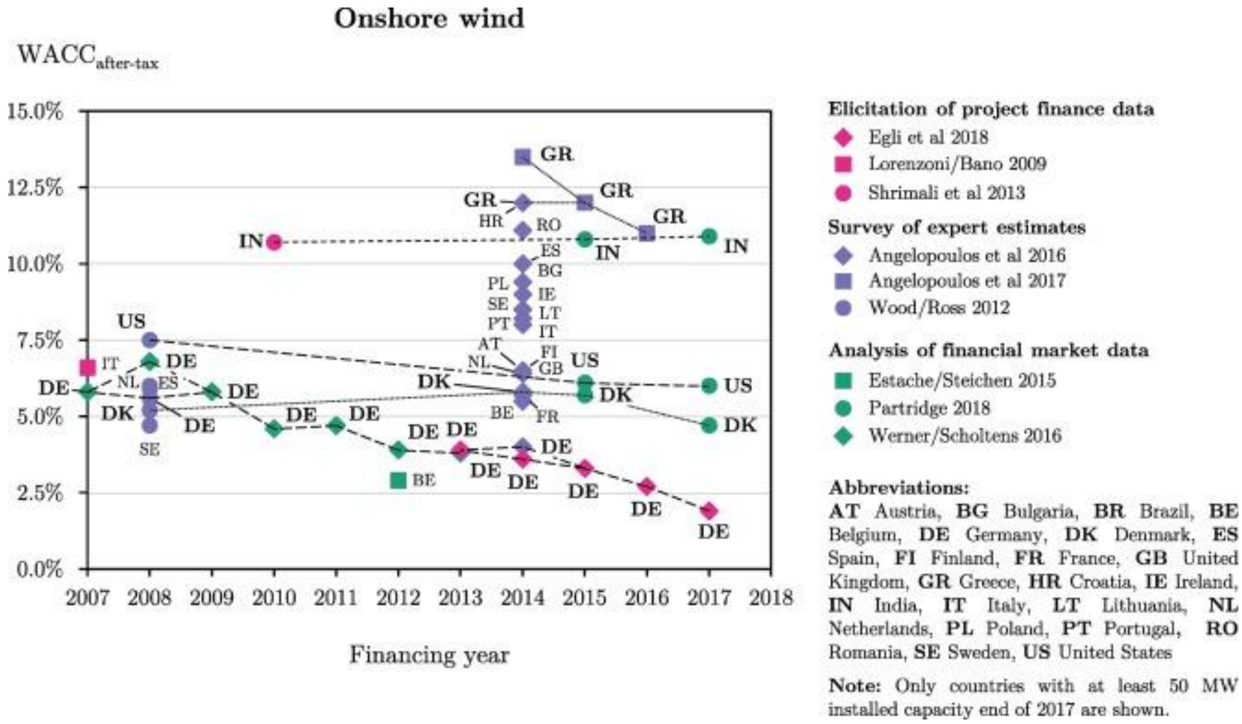


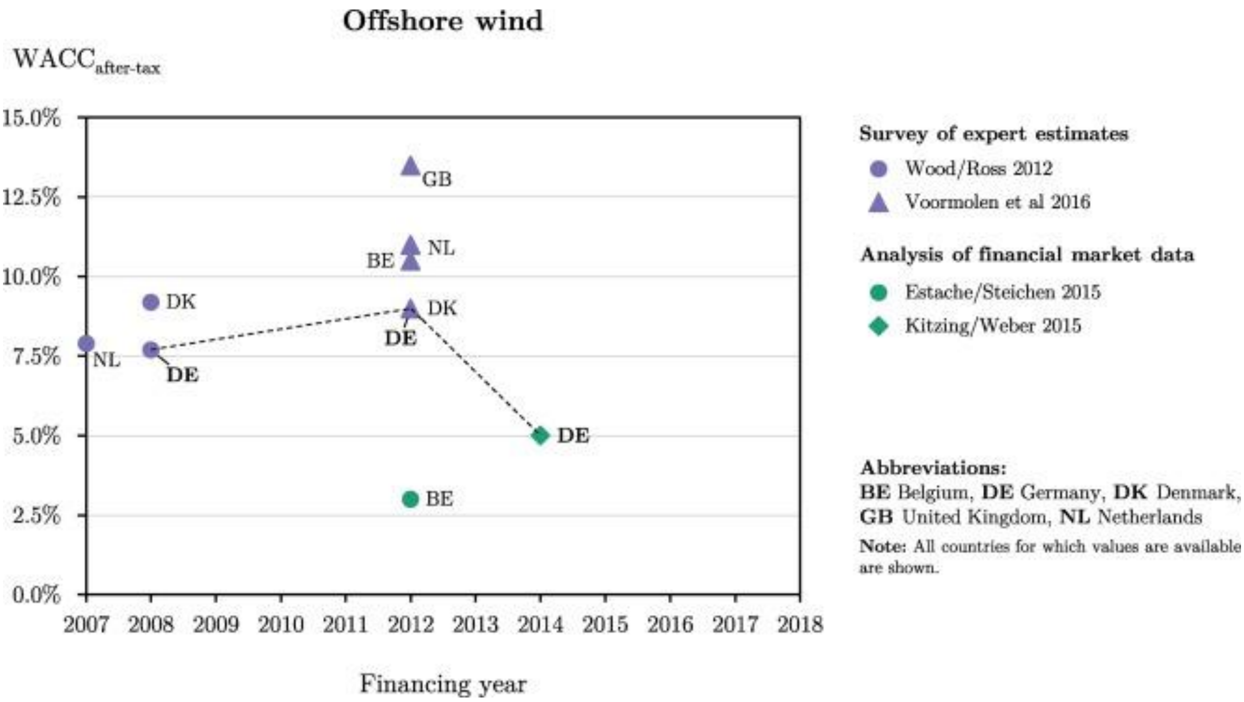
Source: adapted from (Oxera, 2011[12])

A meta-analysis plotting the findings of renewable energy cost of capital studies across different markets over time evidences the dynamic nature of cost of capital and its linkage with market maturity and risk (Steffen, 2020[1]). These results are presented in Figure 2.2 below:

Figure 2.2. Cost of capital over time across markets for solar PV, onshore wind, and offshore wind







Source: (Steffen, 2020[1])

The trend of cost of capital reduction for solar PV and onshore wind is evident in many countries, particularly in Western Europe such as Germany, which have benefited from supportive policy and historically low interest rates since the 2007 global financial crisis. The trend is less evident for large emerging economies such as India where WACC is estimated to have remained around 10% or higher over the period for solar and onshore wind. There are also some interesting data points, for example Mexico, South Africa, and Brazil, where the average WACC is estimated at around 5%, half of that in

Viet Nam as estimated by (Kumar, Anisuzaman and Das, 2017[11]). The data points for offshore wind demonstrate the additional premium associated with the immaturity of the technology and therefore the increase in construction and operational risk. The latest data point for Germany in 2014 does indicate that the risk premium is converging with that of other technologies as the offshore sector began to develop an operational track record and lenders were able to properly assess the risk.

To supplement the limited availability of secondary research for Viet Nam, structured interviews were undertaken with a select number of experts active in the Viet Nam market. This included a foreign bank with a Viet Nam representative office, two large domestic banks, and two developers with portfolios of solar and wind projects. Findings from these interviews are summarised below.

Minimum Equity Return Expectation

Table 2.1 below presents the responses from each of the interviewees on the minimum equity return requirements for investment in Viet Nam's renewable energy sector.

Table 2.1. Minimum equity return expectation interview responses

Interviewee	Minimum equity return expectation	Comments
Foreign Bank	-	Was not in a position to provide an estimate
Domestic Bank	16%	Based assessment on conversations with developers and other industry stakeholders
Domestic Bank	15%	
Renewable energy developer 1	'mid teens'	Suggested mid-teens was a corporate target but would be assessed dependent on project risks
Renewable energy developer 2	13-15%	Depending on technology with solar PV 13%, onshore wind 14%, and (near) offshore 15%

The responses can be validated by comparing them with an equity return expectation estimated using the Capital Asset Pricing Model (CAPM). The CAPM relies on financial market data which is difficult to access or unavailable for Viet Nam. To overcome this a CAPM can be calculated based on data from United States and then uplifted based on a country risk premium for Viet Nam as per the equation below:

Cost of Equity = Rf+β(Rm-Rf+CRP)*
Where:
Rf = Risk free rate – estimated as 10 year US treasury bond yield
β = Stock Beta - a measure of the volatility—or systematic risk— of a security or portfolio compared to the market as a whole
Rm-Rf = Market Risk Premium - difference between the expected return on a market portfolio and the risk-free rate
CRP = Country Risk Premium - additional risk premium to compensate for country risk compared to United States

It must be stressed that the CAPM model as specified above provides an approximation of cost of equity but its accuracy and predictive power has been shown to be diminished when applied in developing country contexts due to the non-normal nature of return distributions in such markets (Donovan and Nuñez, 2012[13]). More complex models can be applied to correct for such issues but for the purpose of validating the interview responses, the above model specification is judged to be sufficient. The CAPM parameters and estimate is presented in Table 2.2 below.

Table 2.2. Minimum equity return expectation estimate using capital asset pricing model

	Estimate	
Risk free rate (Rf)	2.02	Average 10-year US treasury bond 2016-2020. A five year average was selected due to the current near zero rate which is unlikely to be sustained
Stock Beta (β)	1.07	Equity Beta for Green and Renewable Energy sector in US calculated by Damodaran NYU Stern 2020
Market Risk Premium (Rm-Rf)	5.23	Market Risk Premium for US calculated by Damodaran NYU Stern 2020
Country Risk Premium (CRP)	5.29	Viet Nam Country Risk Premium calculated by Damodaran NYU Stern 2020
Cost of Equity	13.28%	

The CAPM returns a cost of equity estimation that is lower but roughly approximates the interview responses. It seems reasonable therefore to predict the minimum equity return expectation at 15%. This cost of equity would be the same for mature technologies such as solar PV and onshore wind. However, given the immaturity of the offshore wind market in Viet Nam, uplifting this value by 5-10% would be required with the view that it would converge over a period of 10 or more years of stable operation and political stability with the cost of equity for more mature technologies as was witnessed in Germany (Figure 2.2).

Overview of the Viet Nam Debt Market

Debt typically makes up 70% or more of the capital structure of a large renewable generation project and therefore the cost of debt holds high significance in the reduction of WACC. The market for long-term debt available to renewable energy projects in Viet Nam is characterised by the following aspects:

- **Banking sector vs. capital markets**: capital markets remain underdeveloped and the banking sector is the primary source of debt available to infrastructure projects. Without liquid capital markets Vietnamese banks have limited options to raise long-term capital or to offload their loan portfolios through securitized instruments. This results in an asset/liability tenor mismatch that is a source of systemic risk for the sector. The State Bank of Viet Nam is sensitive to this issue and passed Circular 8 in 2020, which tightens the maximum ratio of short-term capital sources for medium- and long-term lending from 40% in 2020 to 30% in 2023. This regulation, in addition to the requirement to implement Basel II capital adequacy ratios, will reduce systemic risk but will restrict banks' long-term lending capacity. There is a concern that Vietnamese banks may be reaching this capacity limit with implications for lending to the next phase of renewable energy deployment over the Power Development Plan VIII period.

  Over the long-term, there is a need to develop local capital markets to improve access to long-term capital either by banks or directly through infrastructure bonds. In the short to medium term, there is a greater role for donors and development finance institutions to provide long-term capital through on-lending structures. Export credit agencies (ECAs) can also play a key role by providing loan guarantees to international banks aligned with the tenors of Vietnam's power purchase agreement (PPA) and payback requirements.

- **OECD vs. Domestic (and regional) debt**: The first phase of renewable energy deployment was characterised by low flows of foreign debt capital from OECD countries where interest rates have been at historic lows since the financial crisis in 2007. This was due initially to insufficient feed in tariffs and subsequently concerns over the bankability of the standardized PPA and the limited options for risk mitigation. Another barrier foreign banks face are banking regulations that restrict their ability to take security over immovable project assets such as land use rights. This has meant that for the limited transactions involving foreign banks, domestic banks have acted as security agents.

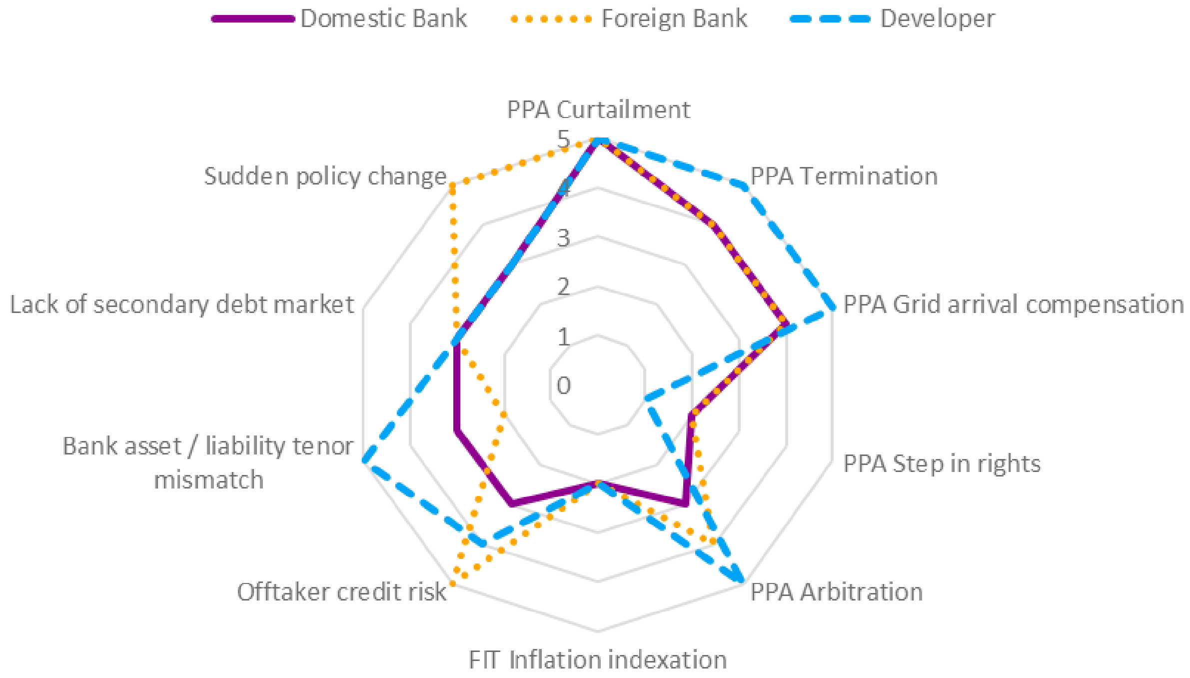
Sovereign guarantees, which have previously been instrumental in mitigating EVN credit risk for fossil fuel projects are no longer available due to the public debt management law. Large domestic banks, who are more familiar and more comfortable with EVN's credit quality and the political context, have to some extent filled this role by offering payment guarantees to enable foreign bank transactions. In this structure, foreign banks lend to projects with support of domestic banks who accept the sector related political and commercial risk. Although this demonstrates the private sector is dynamically adapting to market needs it was noted by the domestic bank interviewee that these transactions have been complicated to negotiate and therefore bring additional costs and delays. With a template agreement and track record in place this will become less of an issue, but scaling up these guarantees will expose domestic banks to significant contingent liabilities and it is uncertain whether they will have the capacity to scale in line with government deployment targets.

- **Project Finance vs. Corporate Finance:** Project finance involves the legal ring fencing of project assets in a special purpose vehicle with debt secured against project assets and cash flows rather than the balance sheet collateral pledged by a parent company. This enables greater structuring options for risk mitigation and facilitates a higher debt ratio. It also enables a greater diversity of investors in the market as the off balance sheet treatment avoids developers from becoming over leveraged and unable to raise more capital for project development. It was estimated by the domestic bank interviewee that around 10% of renewable energy projects that have raised debt financing have used a limited recourse project financing structure. In addition to this, it is thought that a sizable proportion of smaller scale projects (although exact % is unknown) were developed using full equity or with equity-like shareholder loans due to the time constraints in achieving commercial operation prior to feed in tariff expiry dates. Project sponsors would then look to secure debt financing at the operational phase of the project. In markets where project risks are more pronounced and where affordable risk mitigation options are not available project financing structures become less feasible. Furthermore, in immature markets without a history of project financing, transaction costs and lending rates will likely be higher until there is sufficient transaction experience and track record.

Debt Pricing and Leverage Ratios

The interviewees were asked to rate a number of different potential barriers restricting the wider use of project finance structures for renewable energy projects in Viet Nam from 5=critical barrier to 1=not important. The results are presented in Figure 2.3 below:

Figure 2.3. Barriers to project finance structures in Viet Nam's renewable energy sector



Note: PPA = Power purchase agreement; FIT = Feed in tariff;

The foreign bank representative scored a number of the barriers as critical including many of the PPA terms, the risk of sudden policy change, and the off taker credit risk. When asked to judge the most critical barrier the representative pointed to the PPA curtailment risk and lack of take or pay mechanism. It was commented that without this risk mitigated through a revision of the PPA the bank's investment board would not approve financing at any pricing premium. The only structure that would allow them to extend credit to the renewable energy sector is if a local bank bore curtailment risk as well as off taker credit risk. The domestic bank interviewee explained that although they are able to provide payment risk guarantees, they were unable to cover curtailment risk due to the difficulty in assessing which projects may be affected. The risk ratings were generally consistent across respondents apart from the risk of sudden policy change, which was assessed more critically by the foreign bank. In addition, the impact of bank asset/liability tenor mismatch was judged as the highest rating by the developer but was less of a concern for the domestic and foreign bank representatives.

Table 2.3 and Table 2.4 below presents the interview responses on debt pricing and tenor:

Table 2.3. Interview responses from banks on lending terms

	Base Rate	Base Rate 2020 Average (%)	Base Rate 5 year Average (%)	Risk Premium (%)	Total interest rate at 5 year ave. base rate (%)	Tenor (years)	Comments
Domestic Bank	VND Deposit Rate 12 month	4.76	4.87	3.5 – 4.0	8.4 – 8.9	10 – 15	Would reduce lending rate to lower bound risk premium for customers with good payment record and also expressed that with curtailment risk covered (PPA revision) they estimated a reduction in upper bound risk premium to 3.7%. They are more comfortable with solar projects and would require a more experienced sponsor. for wind (onshore and offshore)
Foreign Bank	Euro LIBOR 12 month	0.96	1.85	3.0	4.85	10	Would not change pricing based on technology type but would require different risk mitigants for example for an offshore wind project they would require an established, well-known sponsor with good track record. Currently have not extended credit to projects due to PPA curtailment risk.

Table 2.4. Interview responses from developers on cost of debt financing

	Foreign Hard Currency	Domestic Local Currency
Developer 1	7.5%	Local banks fix a lower interest rate 8.5-9.5% for first two years and then the rate would float on deposit rate plus margin of up to 2.5%-4%
Developer 2	6%-8%	8%-11%

It is clear from the bank responses that in nominal terms, due to the lower base rate and risk premium, the foreign bank's total lending rate is lower than the domestic lender (around 5% vs. 8.5-9%). Accounting for inflation this narrows to around (3.5% for the foreign bank vs 5.5% for the domestic bank). These results were broadly in line with the estimations from developers although the price of foreign debt was estimated slightly higher. Interestingly there was no indication that lending premiums would be differentiated dependent on technology but the lenders would require other risk mitigation such as a more reputable developer.

Putting in place the enabling conditions for cheaper debt financing (both by securing flows from OECD countries and reducing the risk premium of domestic lenders) has potential for Levelised Cost of Energy (LCOE) reduction and cost savings for Vietnamese consumers. It is unlikely that the Vietnamese capital markets will be a viable source of long term, affordable debt in the near term. Driving down the cost of debt via bond markets will also depend on the same sector policies that provide revenue certainty to attract fixed income investors. The revision of the PPA to include a take or pay clause will be a concern to government as it exposes the national utility, EVN, to more risk. It is clear however that EVN is the most suitable stakeholder to manage this risk during the operational phase of a renewable energy project. Scenario analysis in the VEO21 that is able to quantify the potential savings between a high vs low financial hurdle rate based on curtailment mitigation would provide valuable information for the government of Viet Nam to support decision making in this area.

Table 2.5 below presents interview responses on the maximum leverage ratio lenders allow for debt financing.

Table 2.5. Interview responses on leverage ratio

	Leverage Ratio (Debt / Equity)	Comments
Domestic Bank	65 / 35	Generally require 35% equity and this is common across Viet Nam banks. They may consider reducing equity portion to 30% for an existing customer with good track record
Foreign Bank	70 / 30	
Renewable energy developer 1	70 / 30 for foreign bank 60 / 40 for domestic bank	
Renewable energy developer 2	60 / 40	With curtailment protection this could be increased to 80 / 20 for solar PV and 70 / 30 for wind projects

Domestic and foreign banks have approximately the same requirements for maximum leverage with domestic banks generally requiring 5-10% more equity portion from sponsors but allowing this to be reduced for trusted customers. There was little evidence that maximum leverage ratio is differentiated across technologies.

High and Low Renewable Energy WACC Estimates

Based on the interview data, high and low WACC scenarios are estimated below based on a revision of the standardised power purchase agreement to include curtailment protection. The assumptions used and the WACC estimated are presented in Table 2.6 below:

*WACC = Re*E/V+Rd*D/V*(1-Tc)*
Where:
Re = Minimum equity return expectation
E/V = Proportion of total financing that is equity
*Rd = Cost of debt = (OECD debt portion*OECD cost of debt + local and regional debt portion*local and regional cost of debt)*
D/V = Proportion of total financing that is debt
Tc = Corporate tax rate

Table 2.6. High and low weighted average cost of capital estimates for scenario analysis

	High WACC after tax scenario	Low WACC after tax scenario	comments
OECD debt portion (% of total debt)	5	30	5% estimated based on the constraints explained by interviewees to international debt from OECD markets. This would be increased in a scenario of PPA revision
Domestic and regional debt portion (% of total debt)	95	70	As above
OECD price of debt (%)	4.85	4.85	No evidence that the price of debt from OECD lenders would decrease dependent on PPA revision as the current issue is that the PPA restricts lending not the price of lending. There would also be a larger opportunity for export credit agencies to provide affordable lending but this is not factored in.
Domestic price of debt (%)	8.87	8.57	Local debt pricing premium reduced by 30 basis points
Minimum equity return expectation (%)	15	13	2% reduction in equity return expectation estimated to be reasonable based on developer responses
Debt portion (% of total capital)	60	70	Higher leverage enabled with greater revenue certainty.
Equity portion (% of total capital)	40	30	As above
Corporate tax rate (%)	20	20	
Weighted Average Cost of Capital	**10.01%**	**7.29%**	**Recommended to round to 10% and 7.5%**

Based on the interview responses a high and low financing cost scenario can be incorporated as financial hurdle rates into the VEO21 modelling to test the capital cost reduction potential of a PPA revision that would mitigate curtailment risk through a take or pay provision. These financing cost scenarios have been estimated at 10% and 7.5% based on the factors presented in the table above. These financing costs are applicable to mature technologies such as solar PV and onshore wind. Given the immaturity of the offshore wind market in Viet Nam and the additional geopolitical and technical risks that the market would face, these estimations would not apply. Based on expert interviews a 5-10% uplift in the minimum equity return would be required for the first offshore transactions. Furthermore, interviewees felt that given the required scale and capital intensity of offshore wind projects, loan syndications would be required between large multinational and domestic banks. It is clear therefore that the standardised offshore PPA currently applied for nearshore wind projects would not meet the lender requirements to enable such financing and therefore the application of WACC scenarios based on the change in PPA terms would be less applicable.

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