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Applying the Capital Asset Pricing Model in Identifying the Electricity Retail Price in Ho Chi Minh City, Vietnam

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ABSTRACT

This paper applies the capital asset pricing model to calculate the expected return rate equivalent to electricity retail price in Ho Chi Minh City (HCMC), with observed 1464 h of HCMC Power Corporation. The study suggests the model of calculate the electricity retail price so that government has more tools to adjust the electricity prices in electricity market, and recommends an electricity retail price list of 12 levels, with the minimum sale price of 965 VND[1]/kWh and maximum sale price of 1675 VND/kWh. Specifically, with current electricity sale price of 1447 VND/kWh, the HCMC Power Corporation reaches the highest return rate of 11.7% and the return rate fluctuates from −12% to 11.7% (price of 1447 VND/kWh with $r_f = 6\%$). The sensitive analysis shows that from $r_f = 12\%$ above, the return rate always reaches the maximum point at price of 1313 VND/kWh (It is an average cost to produce 1 kWh).

Keywords: Capital Asset Pricing Model, Electricity Retail Price, Electricity Market
JEL Classification: Q4

1 VND is Vietnamese currency, and exchange rate between VND/USD is now about 22,500 VND/USD.

1. INTRODUCTION

Electricity retail tariffs in Vietnam are currently approved by the Prime Minister based the appraisal results of the Ministry of Industry and Trade for the suggestion of Vietnam Electricity (EVN). In the structure of electricity retail tariffs, Electricity Regulatory Authority of Vietnam (ERAV) has regulated the tariff as follows: (i) To increase the price for production load and to decrease the price for households; (ii) to support the price for low-income households and poor households (for first 50 kWh/month); (iii) to be applicable multi-tariffs. All the above characteristics showed the existence of compensation and subsidy between different customer groups through electricity prices. Accordingly, each customer is charged at different rates (Đàm, 2012).

In Vietnam, the electricity price is determined based on the basis of production cost, transmission cost, distribution cost and reasonable profits for business (Ngô, 2012), in which the most importance is the average retail price and retail prices for end-users. However, the method of determining the electricity retail tariff is now mainly based on statistical cost accounting of the sold goods cost of EVN, with the aim to cover losses disregard to the cause and measures to reduce costs. The adjustment is just focused on the increasing prices that are not interested in reducing the price.

To develop a competitive electricity market is the most effective solution to make the electricity price transparency. According to Rothwell and Gómez (2003), the implementation of the restructuring and deregulation of the power sector is to reduce electricity prices through cost savings. To reach the efficient pricing in electricity retail sector and generate optimal benefit for both Retailer Company (RETCO) and customers, the appropriated models which concerned with risk recovery are needed. Efficient retail price is necessary to ensure that the electricity will be used in the most optimal way and both producer and customer will get the maximization of their benefit. On top of that, consumer will be satisfied due to the improvement of transparency in electricity pricing.

In this paper, the electricity retail price will be studied and determined through the capital asset pricing model (CAPM). This method will be concerned as the efficient tool to determine the retail electricity price for the end-users. The rest of the paper is structured as follow: In Section 2 overview of the deregulation of Vietnamese Power sector and fundamental of CAPM approach. Spot market modeling algorithm where the market clearing price (MCP) is generated, is analyzed in Section 3. Data analysis is shown in Section 4. Conclusions and recommendations are given in Section 5.

2. LITERATURE REVIEW

2.1. Competitive Electricity Market and Deregulation of Power Sector in Vietnam

Over the years, the power sector throughout the world has experienced important changes due to deregulation and restructuring (Rothwell and Gómez, 2003). The vertically integrated state-owned power company (PC) is being changed to a new structure which separated generation, transmission and distribution. In the wholesale market, power plants will compete to sell electricity. For the retail market, customers can choose services from various retail companies with the most reasonable price and good quality service. Power transmission and distribution still need to be regulated by the authorities. This model ensures openness, non-discrimination for the components to participate in the market in stages: Generators, retailers and customers.

To withdraw the monopoly in Vietnamese Power sector, to improve transparency in electricity pricing, to reduce amount outstanding of state enterprises, and to improve economic efficiency, deregulation has to be considered. The cost-based power pool model has been chosen for Vietnamese Power sector. Under the cost-based model, generator will bid at their marginal costs (MC) or actual or estimated variable production costs of supply. The system marginal price can be verified by short-run MC which is consisted of operating, maintenance and fuel cost of the marginal plant.

Since the market is being formed. The state-owned Vietnam Electricity (EVN) still dominates Vietnam's electricity sector, directly and indirectly controlling most generation, transmission, distribution, bulk power and retail power supply activities. EVN plays the following key roles in the pilot market.

2.1.1. System operator (SO)/market operator (MO)

EVN's National Load Dispatch Center (NLDC) is charged with the roles of SO/MO in the Market. The NLDC is therefore responsible for thermal and hydro scheduling and dispatching. In addition the NLDC is also responsible for hydro resources management which includes reservoir operations, flood control and irrigation.

2.1.2. Single buyer (SB)

EVN acts as the SB and trader for wholesale electricity in the Market. The EVN SB procures the energy its needs to supply EVN PCs from EVN's generation companies and submits about 75% of the energy bids to the MO via the Power Pool web site.

2.1.3. EVN generator companies (GENCOs)

EVN remains the owner and operator of the generation units declared by the Government as strategically important generators. These units have been identified as the three largest multipurpose hydroelectric complexes in the country. In addition, under its current re-structuring plan EVN has retained majority ownership (over 51%) of all equitized generation units, giving EVN control over most of the existing generation in the country. EVN owned and controlled generators are capable of offering their bids directly into the market via the power pool web based portal.

2.1.4. Transmission owner/operator

EVN also owns and operates transmission company responsible for the 500 kV, 220 kV and some 110 kV transmission assets. This includes oversight of interconnections agreements between new IPPs and BOTs and EVN.

2.1.5. Distribution owner/operator

The 05 distribution companies (RETCOs) responsible for distribution asset management (up to 110 kV), procuring power from EVN at the internal price and in turn, selling the power to their franchise customers at tariffs approved by the Prime Minister.

In 2011, Vietnam introduced its competitive generation market (CGM) in pilot form, which moved to full operation in 2012. Under the CGM, generators compete in an hourly spot market to sell power to a SB, the Electric Power Trading Corporation which is a dependent unit within EVN. Currently, PCs hold a monopoly over sales to all electricity customers in their service areas. Under the power sector reform roadmap approved by the Prime Minister, large customers will be allowed to purchase directly from generators from 2015 onwards. From 2022, with the start of full retail competition, all customers will be allowed to choose their electricity supplier and PCs will no longer hold a monopoly over electricity sales. They will continue to be the monopoly owner and operator of the distribution network in their service areas and will charge a fee for use of this network by other suppliers. In conclude, Vietnam electricity market will be formed and developed in three phases as follows: (i) CGM (2009-2015), (ii) competitive wholesale market (2016-2025), (iii) competitive retail market (after 2025).

2.2. CAPM

A CAPM is a simple relationship that links the return on particular stock with the return on portfolio made up of the entire market (Hull, 2003). The CAPM model is widely used as measure of risk in the portfolio investment.

$$E(r_j - r_f) = \beta_j \times E(r_m - r_f) \tag{1}$$

Where,

$E(r_j - r_f)$ is called the expected excess rate of return of asset j.
$E(r_m - r_f)$ is called the expected excess rate of return of the market portfolio.
β_j is normalized covariance between j^{th} asset and total portfolio returns.

$$\beta_j = \frac{COV(r_j, r_m)}{VAR(r_m)} \tag{2}$$

As $E(r_f) = r_f$:

$$E(r_j) - r_f = \beta_j \times E(r_m - r_f) \quad (3)$$

Under the CAPM, the expected return $E(r_j)$ of any asset j satisfies:

$$E(r_j) = r_f + \beta_j \times E(r_m - r_f) \quad (4)$$

r_j is return of any asset j,
r_m is rate of market return,
r_f is risk free rate of return.

Where,

- If $\beta_j = 0$ then expected return of asset j is risk free rate of return,
- If $\beta_j = 1$ then asset j has the risk of market and expected return equal to r_m,
- If $\beta_j > 1$ then the risk of asset j is higher than that of market and expected return higher than r_m,
- If $\beta_j < 1$ then the risk of asset j is less than that of market and expected return less than r_m.

The CAPM model can be appropriately used for RETCOs who invest the payment received from end users in GENCOs in competitive market (Karandikar et al., 2007). In model, risk will be considered as variance and for any capital the total variance of return must be minimized. The price change will affect the estimation of asset returns, thus the RETCOs will recalculate their projected price, which will be offered to the customer, until both demand and supply are matched.

The CAPM model can be appropriately used for determining the retail tariff in order to regulate RETCOs in competitive market (Karandikar et al., 2007).

The expected rate of return of retailer from one generator is determined using CAPM model is as follows:

$$E(r_g) = \beta[E(r_m) - r_f] + r_f \quad (5)$$

Where,

$E(r_g)$ is expected rate of return from generator,
β is normalized co-variance between profit from generator and total profit of retailer,
$E(r_m)$ is expected rate of market return of each portfolio i.e., each generator and is a ratio of generator mean profit and mean of total profit,
r_f is risk free rate of return.

In case that β is almost zero, then the asset is completely uncorrelated with the market. Accordingly, in this case, the expected return is the risk free rate. If $E(r_j) < r_f$, the asset may face the high risk. Under this circumstance, RETCOs will accept the lower expected value by concern some forms of insurance. For conclusion, the RETCOs can quantify their business risk by applying CAPM model for the different tariffs.

3. METHODOLOGY

In the spot market, the GENCOs have to bid their price and quantity of their generated electricity to the electricity pool. Ho Chi Minh city (HCMC) Power Corporation will get fixed rate of return, controlled by ERAV, while they purchase from volatile market which the price can be change all the time and hardly to be predicted. The calculation in this study as follows:

- Step 1 – Generating the spot price: The time length in this study is 1464 h in the period of May and June of 2013 from May 01, 2013 to June 30, 2013 in the area of HCMC. The data needed are load demand and power supply for HCMC during 2 months period of May and June in 2013.
- Step 2 – Determination of β which is normalized co-variance between profit from generator supply power for HCMC and total profit of EVNHCMC: Using the calculated MCP and proposed retail tariff to determine the expected return in each hour of 1464 h of each unit of generator. Divide the variance of rate of return of market by covariance of expected return of generators and profit of EVNHCMC.
- Step 3 – Using CAPM to calculate the expected rate of return of EVNHCMC.
- Step 4 – Data analysis to determine the appropriate electricity retail tariff for regulate PCs in power competitive market.

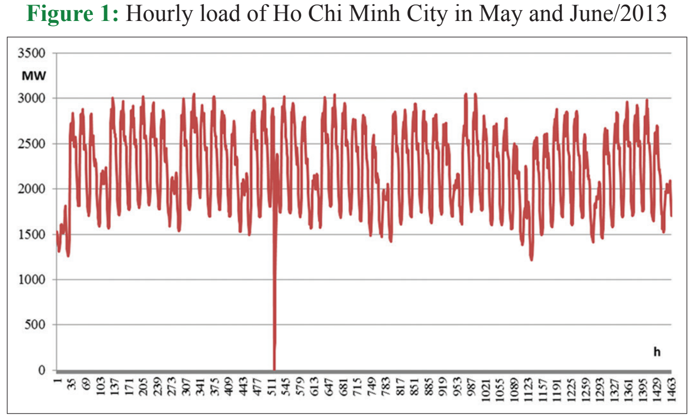
3.1. Data Collection

The load for this study is varying hour to hour. The maximum load is 3047.8 MW, the minimum is 0 MW, and the average is 2,288.7 MW. Figure 1 gives the total load variation for the 1464 h.

For generating the spot market, the supply and demand curves have to be generated. As for supply curve generating, the power plants and generators data are required, such as power plant capacity, force outage rate, spinning reserve, and short-run MC (fuel cost, fixed and variable operating and maintenance cost), etc. (Pasapong and Charles, 2011). Power plant selection to supply power for HCMC has to meet followings criteria:

- HCMC is in the Southern of Vietnam; therefore, the power plants are dispatched to supply power for HCMC in the state of optimum power flow
- These plants must be in the list of plans that are participate in the CGM.

Figure 1: Hourly load of Ho Chi Minh City in May and June/2013



Source: EVNHCMC (2013)

As the result, the 6 plants with 21 generators are selected which are shown in Table 1. This list is also the investment portfolio of EVNHCMC.

3.2. MCP generating

The following spot market algorithms shortly describe how the model will be worked. Starting from the 1st of May to 30th of June in year 2013, the following steps were performed:

- At the beginning of each simulated hour, the model will uses the demand data between EVNHCMC and GENCOs
- The model permits each generating unit the offer only one bid into the system or the pool. Each generator will use their SRMC as the offered price
- The model then builds the stair-step supply curve ranked according to the plants' merit order and the industry supply at each hourly basis.

According with the auction approach and the actual dispatch schedule that happening in May and June in 2013 provided by EVN, the MCP at the given hour will be equal to the SRMC of last generator who allocate their electricity to the pool and make the total load demand equal to the supply offer. For example, on the 1st h where the load needed is 1532.9 MW, the selected generator, who has been selected as the last bidder in the system at that hour, is PHU_MY_21_GT22 (code name: G10). Thus, the MCP of the system at 1st h will be equal to G10 SRMC which is 580 VND/kWh (Figure 2). The generators (from G3 to G9) could not run at full load due to periodically maintenance so the last selected generator is G10.

Hence, as for remaining 1463 h, the process will be continued as same as the 1st h process. The results reveal that the MCP varies from 612 to 3359 VND/kWh (Figure 3).

3.3. Proposal of Retail Tariff and Calculating β

Retail tariff is set by government based on following costs: Generation cost, transmission cost, distribution cost and auxiliary services fee. In this paper, the determined average generation cost of 1 kWh is 1.019VND; adding up with generation cost, transmission cost, distribution cost and auxiliary services fee defined are as follows:

- Transmission cost = 73 VND/kWh
- Distribution cost = 216 VND/kWh
- Auxiliary services fee = 5 VND/kWh

Average retail price for 1 kWh = 1.019 + 3 + 216 + 5 = 1.313 VND/kWh.

EVNHCMC has invested in 21 generators; the average cost for all 21 generators is 6.2 USc/kWh. Follow with this cost per kWh, the range of proposed fixed retail price will start from 965 VND to 1675 VND (Table 2). This assumption with ±5% of average retail price is based on the Decision by Government that allowing EVN to adjust the retail price if the proposed increase/decrease price is lower than 5% of current price.

Figure 2: The process to determine market clearing price on the 1st h

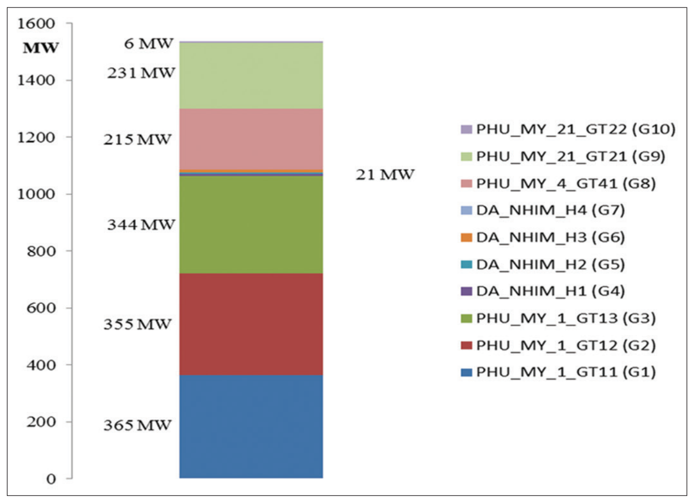


Table 1: The description of selected generators (arranged with respect to merit order)

Code name	Generator	Plant	Type	Bid capacity (MW)	Bid price (VND/kWh)	Accumulation power (MW)
G1	PHU_MY_1_GT11	Phu My 1	CCGT	365	580	365
G2	PHU_MY_1_GT12	Phu My 1		365	580	730
G3	PHU_MY_1_GT13	Phu My 1		365	580	1095
G4	DA_NHIM_H1	Da Nhim	Hydropower	41,5	589	1136.5
G5	DA_NHIM_H2	Da Nhim		41,5	589	1178
G6	DA_NHIM_H3	Da Nhim		41,5	589	1119.5
G7	DA_NHIM_H4	Da Nhim		41,5	589	1261
G8	PHU_MY_4_GT41	Phu My 4	CCGT	245	603	1506
G9	PHU_MY_21_GT21	Phu My 2.1	CCGT	245	612	1751
G10	PHU_MY_21_GT22	Phu My 2.1		245	612	1966
G11	PHU_MY_21_GT24	Phu My 2.1		245	612	2241
G12	PHU_MY_21_GT25	Phu My 2.1		245	612	2486
G13	NHON_TRACH_2_GT5	Nhon Trach 2	CCGT	385	819	2871
G14	NHON_TRACH_2_GT6	Nhon Trach 2		385	819	3256
G15	PHU_MY_4_GT42	Phu My 4	CCGT	245	827	3501
G16	NHON_TRACH_1_GT11	Nhon Trach 1	CCGT	230	883	3731
G17	NHON_TRACH_1_GT12	Nhon Trach 1		230	883	3961
G18	HAM_THUAN_H1	Ham Thuan	Hydropower	150	1.015	4111
G19	HAM_THUAN_H2	Ham Thuan		150	1.918	4261
G20	DA_MI_H1	Da Mi	Hydropower	87	3.539	4348
G21	DA_MI_H2	Da Mi		87	3.539	4435

Source: EVN (2013). EVN: Vietnam Electricity

Then, calculating expected profit of generator(s) and EVNHCMC's profit as follows:
- Expected profit of 1 generator = (MCP – Cost for running of 1 kWh) × Capacity of generator
- Expected profit EVNHCMC = (Retail price × Power demand) – (MCP × Power supply).

For example, with the price of 965 VND/kWh and the information provided for generator G1 is:
- Expected profit of G1 = (612–580) × 365 = 11.680.000 VND
- Expected profit of EVNHCMC = (965 × 1532.9) – (612 × 1.537) = 538.337.175 VND.

Doing above calculations for the rest of 1463 h with 11 retail prices indicating in Table 2.

Then calculating β of 21 generators: $\beta_j = \dfrac{COV(r_j, r_m)}{VAR(r_m)}$

And expected return of the market Er_m.

$$Er_m = \frac{\text{Average profit of generators}}{\text{Average profit of EVNHCMC}}$$

4. DATA ANALYSIS

After load demand, selected generators and MCP are determined, the CAPM model can be used to find the effective rate of retail price for retailer to gain the highest of EVNHCMC's return. According to different offered fixed retail price, β of different generators (Figure 4 and Table 3) and expected return of retailer from each generator are determined. In present case, risk free rate of return is assumed 6%, 8%, 10%, and 12%. Table 4 is shown β results while Tables 5-8 are represented expected rate of return and average value for all generators at different fixed retail price at each assumed risk free rate.

Generators G20 and G21 of Da Mi Hydropower has the highest bid price of 3.539 VND/kWh so they have not been chosen to dispatch; therefore, no revenue for generator to calculate β.

As for G16 has β = 0. Thus, the expected rate of return of G16 unit will be risk-free rate.

The result shows that with current electricity sale price of 1447 VND/kWh, the HCMC Power Corporation reaches the highest return rate of 11.7% and the return rate fluctuates from −12% to 11.7% (price of 1,447 VND/kWh with r_f = 6%). The sensitive analysis shows that from r_f = 12% above, the return rate always reaches the maximum point at price of 1313 VND/kWh (It is an average cost to produce 1 kWh).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

To perform preliminary analysis of efficient electricity retail price in competitive market by using quantitative methods is the main

Figure 3: The market clearing price for all 1464 h

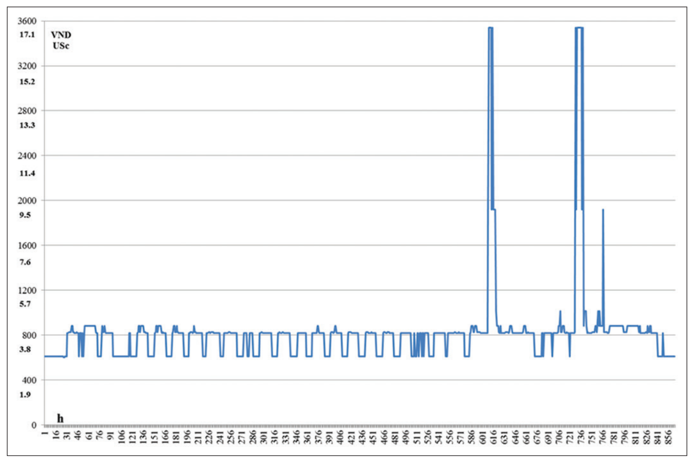


Figure 4: β of different generators

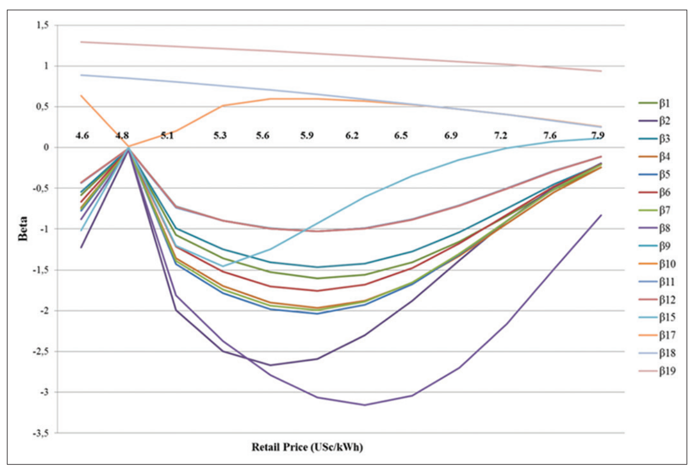


Table 2: Proposed fixed retail price of EVNHCMC

	1	2	3	4	5	6	7	8	9	10	11	12
Retail price (VND/kWh)	965	1.016	1.069	1.125	1.185	1.247	1.313	1.378	1.447	1.519	1.595	1.675

EVNHCMC: Vietnam Electricity Ho Chi Minh City

Table 3: Expected profit of G1 and EVNHCMC in 1st h with the price of 4.6 USc/kWh

Hour	Gen	Capacity (MW)	Bid price (VND/kWh)	MCP (VND/kWh)	Expected profit of G1 (10^3 VND)	Demand (MW)	Supply (MW)	EVNHCMC's profit ($)
1	G1	365	580	612	11.680	1.532,9	1.537	538.337

EVNHCMC: Vietnam Electricity Ho Chi Minh City, MCP: Market clearing price

Table 4. β **of different generators**

Retail price VND/kWh	β1	β2	β3	β4	β5	β6	β7	β8	β9	β10	β11
965	−0.58599	−1.22454	−0.54715	−0.73548	−0.77298	−0.66339	−0.75258	−0.87853	−0.43146	−0.43185	−0.43623
1.016	−0.02141	−0.03174	−0.01882	−0.02405	−0.02535	−0.01991	−0.02435	−0.02891	−0.01565	−0.01561	−0.02079
1.069	−1.07342	−1.99089	−0.9917	−1.35652	−1.42872	−1.21469	−1.39164	−1.81214	−0.72295	−0.72352	−0.73828
1.125	−1.35489	−2.49787	−1.24842	−1.69893	−1.78432	−1.52313	−1.74009	−2.37133	−0.89358	−0.89461	−0.89796
1.185	−1.5284	−2.66543	−1.4034	−1.89695	−1.9816	−1.70016	−1.93567	−2.78586	−0.99168	−0.99292	−0.99302
1.247	−1.60255	−2.58868	−1.46567	−1.96272	−2.03389	−1.75754	−1.9912	−3.06258	−1.02658	−1.0278	−1.02632
1.313	−1.56017	−2.29853	−1.42018	−1.879	−1.92547	−1.67942	−1.89066	−3.15767	−0.98818	−0.98911	−0.9868
1.378	−1.4055	−1.87712	−1.27226	−1.65934	−1.67607	−1.47841	−1.65194	−3.04007	−0.87974	−0.88018	−0.87756
1.447	−1.15292	−1.38628	−1.03622	−1.32767	−1.3152	−1.17706	−1.30284	−2.70078	−0.70976	−0.70961	−0.70708
1.519	−0.83868	−0.90246	−0.74661	−0.93551	−0.90169	−0.82326	−0.89969	−2.16045	−0.50143	−0.50085	−0.49865
1.595	−0.51624	−0.49056	−0.45294	−0.55157	−0.5097	−0.47959	−0.5144	−1.49506	−0.28954	−0.2888	−0.28708
1.675	−0.24215	−0.19281	−0.20631	−0.24202	−0.20619	−0.20478	−0.21287	−0.83278	−0.11178	−0.11118	−0.10995

Retail price VND/kWh	β12	β13	β14	β15	β16	β17	β18	β19	β20	β21
965	−0.43244	−9.48887	−9.47603	−1.01493	0	0.63564	0.88762	1.28978	–	–
1.016	−0.01568	−0.34801	−0.34567	0.001891	0	0.0171	0.8459	1.26483	–	–
1.069	−0.72483	−16.2922	−16.245	−1.2057	0	0.20271	0.80147	1.23853	–	–
1.125	−0.89613	−20.9705	−20.9142	−1.45339	0	0.51292	0.75409	1.2108	–	–
1.185	−0.9948	−23.7991	−23.7341	−1.24943	0	0.59522	0.7035	1.18157	–	–
1.247	−1.03013	−25.1083	−25.0368	−0.92704	0	0.59739	0.6494	1.15077	–	–
1.313	−0.99193	−24.6664	−24.5928	−0.60739	0	0.56729	0.59147	1.11829	–	–
1.378	−0.88339	−22.5396	−22.4693	−0.34985	0	0.52278	0.53247	1.08577	–	–
1.447	−0.71296	−18.963	−18.9016	−0.15064	0	0.46787	0.46931	1.05157	–	–
1.519	−0.50389	−14.4562	−14.4084	−0.01006	0	0.40465	0.40161	1.01562	–	–
1.595	−0.29107	−9.73104	−9.69913	0.076189	0	0.33399	0.32899	0.97783	–	–
1.675	−0.11241	−5.49974	−5.48277	0.113601	0	0.25628	0.2511	0.93809	–	–

Table 5: Expected return for each generator at risk free rate 6%

Retail price VND/kWh	E_{rg1}	E_{rg2}	E_{rg3}	E_{rg4}	E_{rg5}	E_{rg6}	E_{rg7}	E_{rg8}	E_{rg9}	E_{rg10}	E_{rg11}	E_{rg12}	E_{rg13}	E_{rg14}	E_{rg15}	E_{rg16}	E_{rg17}	E_{rg18}	E_{rg19}	$Er_{EVNHCMC}$
965	−0.58	−1.24	−0.44	0.04	0.03	0.07	0.04	−0.30	−0.17	−0.14	−0.16	−0.15	0.19	0.38	0.10	0.06	0.02	0.01	−0.02	−0.12
1.016	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.06	0.01	−0.02	0.05
1.069	−0.59	−1.11	−0.43	0.07	0.07	0.10	0.07	−0.32	−0.14	−0.11	−0.14	−0.13	0.61	0.78	0.12	0.06	0.05	0.01	−0.01	−0.05
1.125	−0.59	−1.10	−0.43	0.09	0.09	0.12	0.09	−0.32	−0.13	−0.10	−0.12	−0.12	0.87	1.05	0.13	0.06	0.03	0.01	−0.01	−0.02
1.185	−0.54	−0.95	−0.39	0.11	0.11	0.13	0.11	−0.29	−0.11	−0.08	−0.10	−0.09	1.06	1.23	0.13	0.06	0.02	0.02	−0.01	0.02
1.247	−0.46	−0.76	−0.33	0.12	0.12	0.14	0.12	−0.24	−0.08	−0.06	−0.07	−0.07	1.18	1.34	0.11	0.06	0.02	0.02	−0.01	0.06
1.313	−0.37	−0.55	−0.25	0.13	0.12	0.14	0.12	−0.18	−0.05	−0.03	−0.04	−0.04	1.21	1.34	0.09	0.06	0.03	0.02	−0.01	0.09
1.378	−0.27	−0.36	−0.18	0.12	0.12	0.13	0.12	−0.12	−0.02	0.00	−0.01	−0.01	1.15	1.25	0.08	0.06	0.03	0.03	−0.01	0.11
1.447	−0.17	−0.21	−0.11	0.11	0.11	0.12	0.11	−0.07	0.01	0.02	0.01	0.01	1.00	1.08	0.07	0.06	0.03	0.03	0.00	0.12
1.519	−0.09	−0.09	−0.04	0.10	0.10	0.10	0.10	−0.02	0.03	0.04	0.03	0.03	0.79	0.85	0.06	0.06	0.04	0.04	0.00	0.11
1.595	−0.02	−0.01	0.01	0.08	0.08	0.08	0.08	0.02	0.05	0.05	0.05	0.05	0.56	0.59	0.06	0.06	0.04	0.04	0.00	0.10
1.675	0.03	0.04	0.04	0.07	0.07	0.07	0.07	0.04	0.06	0.06	0.06	0.06	0.35	0.36	0.05	0.06	0.04	0.04	0.00	0.08

For the price at 1.447VNĐ/kWh. the average rate of return is maximum.

Table 6: Expected return for each generator at risk free rate 8%

Retail price VND/kWh	E_{rg1}	E_{rg2}	E_{rg3}	E_{rg4}	E_{rg5}	E_{rg6}	E_{rg7}	E_{rg8}	E_{rg9}	E_{rg10}	E_{rg11}	E_{rg12}	E_{rg13}	E_{rg14}	E_{rg15}	E_{rg16}	E_{rg17}	E_{rg18}	E_{rg19}	$Er_{EVNHCMC}$
965	−0.55	−1.19	−0.40	0.07	0.07	0.10	0.07	−0.26	−0.14	−0.11	−0.13	−0.12	0.40	0.58	0.14	0.08	0.03	0.01	−0.02	−0.07
1.016	0.06	0.06	0.07	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.07	0.07	0.10	0.10	0.08	0.08	0.08	0.01	−0.02	0.07
1.125	−0.54	−1.03	−0.39	0.15	0.14	0.17	0.14	−0.25	−0.09	−0.07	−0.09	−0.08	1.31	1.49	0.18	0.08	0.04	0.02	−0.02	0.06
1.185	−0.49	−0.88	−0.34	0.17	0.17	0.18	0.17	−0.21	−0.07	−0.04	−0.06	−0.05	1.56	1.73	0.17	0.08	0.03	0.02	−0.01	0.11
1.247	−0.41	−0.68	−0.28	0.18	0.18	0.19	0.18	−0.16	−0.04	−0.02	−0.03	−0.03	1.70	1.86	0.15	0.08	0.03	0.03	−0.01	0.15
1.313	−0.31	−0.48	−0.20	0.18	0.18	0.19	0.18	−0.10	−0.01	0.01	0.00	0.00	1.73	1.86	0.13	0.08	0.03	0.03	−0.01	0.18
1.378	−0.22	−0.31	−0.13	0.18	0.17	0.18	0.17	−0.04	0.02	0.03	0.02	0.03	1.62	1.72	0.11	0.08	0.04	0.04	−0.01	0.19
1.447	−0.13	−0.16	−0.06	0.16	0.16	0.16	0.16	0.01	0.04	0.05	0.05	0.05	1.40	1.48	0.09	0.08	0.04	0.04	0.00	0.19
1.519	−0.05	−0.05	−0.01	0.14	0.13	0.14	0.14	0.05	0.06	0.07	0.06	0.06	1.10	1.15	0.08	0.08	0.05	0.05	0.00	0.17
1.595	0.01	0.02	0.04	0.12	0.11	0.11	0.11	0.07	0.07	0.08	0.07	0.07	0.78	0.81	0.07	0.08	0.05	0.05	0.00	0.14
1.675	0.05	0.06	0.06	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.48	0.49	0.07	0.08	0.06	0.06	0.00	0.12

* For the price at 1.378VNĐ/kWh. the average rate of return is maximum.

Table 7: Expected return for each generator at risk free rate 10%

Retail price VND/kWh	E_{rg1}	E_{rg2}	E_{rg3}	E_{rg4}	E_{rg5}	E_{rg6}	E_{rg7}	E_{rg8}	E_{rg9}	E_{rg10}	E_{rg11}	E_{rg12}	E_{rg13}	E_{rg14}	E_{rg15}	E_{rg16}	E_{rg17}	E_{rg18}	E_{rg19}	$Er_{EVNHCMC}$
965	−0.51	−1.15	−0.37	0.11	0.11	0.13	0.11	−0.22	−0.11	−0.08	−0.10	−0.09	0.61	0.79	0.18	0.10	0.04	0.01	−0.03	−0.03
1.016	0.08	0.08	0.09	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.10	0.12	0.13	0.10	0.10	0.10	0.02	−0.03	0.09
1.069	−0.50	−0.99	−0.35	0.17	0.17	0.19	0.17	−0.21	−0.07	−0.04	−0.07	−0.06	1.30	1.47	0.21	0.10	0.08	0.02	−0.02	0.08
1.125	−0.49	−0.96	−0.34	0.20	0.20	0.22	0.20	−0.19	−0.06	−0.03	−0.05	−0.04	1.75	1.93	0.23	0.10	0.05	0.02	−0.02	0.14
1.185	−0.44	−0.80	−0.29	0.22	0.23	0.24	0.22	−0.13	−0.03	0.00	−0.02	−0.01	2.05	2.22	0.22	0.10	0.04	0.03	−0.02	0.20
1.247	−0.36	−0.61	−0.23	0.24	0.24	0.25	0.24	−0.08	0.00	0.02	0.01	0.01	2.23	2.38	0.19	0.10	0.04	0.04	−0.02	0.25
1.313	−0.26	−0.42	−0.16	0.24	0.24	0.24	0.24	−0.01	0.03	0.05	0.04	0.04	2.24	2.37	0.16	0.10	0.04	0.04	−0.01	0.27
1.378	−0.17	−0.25	−0.09	0.23	0.23	0.23	0.23	0.04	0.06	0.07	0.06	0.06	2.09	2.19	0.13	0.10	0.05	0.05	−0.01	0.28
1.447	−0.09	−0.11	−0.02	0.21	0.20	0.20	0.20	0.08	0.08	0.09	0.08	0.08	1.80	1.88	0.11	0.10	0.05	0.05	−0.01	0.26
1.519	−0.01	−0.02	0.03	0.18	0.17	0.17	0.17	0.11	0.09	0.10	0.09	0.09	1.41	1.46	0.10	0.10	0.06	0.06	0.00	0.23
1.595	0.04	0.05	0.06	0.15	0.14	0.14	0.14	0.12	0.10	0.10	0.10	0.10	0.99	1.02	0.09	0.10	0.07	0.07	0.00	0.19
1.675	0.08	0.08	0.09	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.61	0.62	0.09	0.10	0.07	0.07	0.01	0.15

*For the price at 1.378VNĐ/kWh. the average rate of return is maximum.

Table 8: Expected return for each generator at risk free rate 12%

Retail price VND/kWh	E_{rg1}	E_{rg2}	E_{rg3}	E_{rg4}	E_{rg5}	E_{rg6}	E_{rg7}	E_{rg8}	E_{rg9}	E_{rg10}	E_{rg11}	E_{rg12}	E_{rg13}	E_{rg14}	E_{rg15}	E_{rg16}	E_{rg17}	E_{rg18}	E_{rg19}	$Er_{EVNHCMC}$
965	−0.48	−1.10	−0.34	0.14	0.14	0.17	0.14	−0.19	−0.08	−0.05	−0.07	−0.07	0.82	1.00	0.22	0.12	0.04	0.01	−0.03	0.02
1.016	0.10	0.10	0.11	0.12	0.12	0.12	0.12	0.11	0.12	0.12	0.11	0.12	0.15	0.15	0.12	0.12	0.12	0.02	−0.03	0.11
1.069	−0.46	−0.93	−0.31	0.21	0.21	0.23	0.21	−0.15	−0.04	−0.01	−0.03	−0.02	1.64	1.82	0.25	0.12	0.10	0.02	−0.03	0.15
1.185	−0.38	−0.73	−0.24	0.28	0.29	0.29	0.28	−0.06	−0.01	0.04	0.02	0.02	2.55	2.72	0.26	0.12	0.05	0.04	−0.02	0.29
1.247	−0.30	−0.54	−0.18	0.30	0.30	0.30	0.30	0.01	0.04	0.06	0.05	0.05	2.75	2.90	0.23	0.12	0.05	0.04	−0.02	0.34
1.313	−0.21	−0.35	−0.11	0.30	0.30	0.30	0.30	0.07	0.07	0.09	0.08	0.08	2.75	2.88	0.19	0.12	0.05	0.05	−0.01	0.37
1.447	−0.04	−0.07	0.02	0.25	0.25	0.25	0.25	0.16	0.11	0.12	0.11	0.12	2.20	2.27	0.14	0.12	0.06	0.06	−0.01	0.34
1.519	0.02	0.02	0.06	0.22	0.21	0.21	0.21	0.17	0.12	0.13	0.12	0.12	1.72	1.77	0.12	0.12	0.07	0.07	0.00	0.29
1.595	0.07	0.08	0.09	0.18	0.17	0.17	0.17	0.17	0.12	0.13	0.12	0.13	1.21	1.24	0.11	0.12	0.08	0.08	0.00	0.23
1.675	0.10	0.11	0.11	0.15	0.14	0.14	0.14	0.15	0.12	0.12	0.12	0.12	0.74	0.75	0.11	0.12	0.09	0.09	0.01	0.18

*For the price at 1.313VNĐ/kWh. the average rate of return is maximum.

objective for this study. CAPM which is used for determining the expected return from the 21 generators, that EVNHCMC has invested in.

The necessary data which is needed for using in CAPM is the MCP for each hour. The MCP varies due to the demand and power supply for HCMC, while the fixed price is applied for retail price of EVNHCMC. Fortunately, Vietnam has operated the CGM that is generating MCP for this study.

The study suggests the model of calculate the electricity retail price so that government has more tools to adjust the electricity prices in electricity market, and recommends an electricity retail price list of 12 levels, with the minimum sale price of 965 VND/kWh and maximum sale price of 1675 VND/kWh. For EVNHCMC, the RETCO, the risk from MCP in electricity market has to be considered and added to the retail price thanks to applying CAPM. As the result from CAPM, ERAV may to fix the retail price at 1313 VND/kWh for EVNHCMC gaining the highest return.

For the meaning of β: At the price of 965VND/kWh, G19 (unit of Ham Thuan hydropower H2) gains the highest β at 1.29. That means if the market returns increases 1 times then profit of G19 increases 1.29 times. Meanwhile, at the price of 965 VND/kWh, G13 (unit of thermal power GT5 Nhon Trach 2) gains the smallest β at −25.11. That means if the market profit increases 1 times then G13 profit decreases 25.11 times. Conclusion, if $\beta > 0$, then the expected profit of units has the same direction as the market returns. If $\beta < 0$, then the expected profit of units has the opposite direction of the market returns. $\beta = 0$, the expected rate of return of generator will be risk-free rate (in case of unit G16). In this study, the price of 1016 VND/kWh makes the β equal 0.

Regarding the relationship between β, MCP and retail price: The higher MCP, the higher profit for generators, the lower profit for EVNHCMC. The higher retail price, the higher profit for EVNHCMC, still the profit for generator unchanged. β of generators is correlated with MCP and inversely correlated with retail prices.

For the expected rate of return of EVNHCMC: The expected rate of return of EVNHCMC varies from −12% to 11.7%. Sensitivity analysis shows that the highest rate of return is 36.5% at 1313 VND/kWh with $r_f = 12\%$. In scenario with $r_f = 12\%$ or over, the expected rate of return of EVNHCMC always peaked at 1313 VND/kWh which is the average cost to produce 1 kWh of electricity.

5.2. Recommendations

Recommendations for the future work are suggested as follows:

There are only 1464 h considered as the time length in this study. Thus, the future study should be considered more hour period in order to generate more accurate result.

In this study, the MCP is generated with the auction approach. In reality, EVN has the software to stimulate all the process to generating the spot prices. To approach this software is expected to have more concrete results.

Study on other prices and charges that make up retail prices such as wholesale price, transmission and distribution charge, etc.

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