

## Energy Efficiency Incentives in Retrofit Financing in Indonesia

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### ABSTRACT

The new financial model that provides monetary investment on savings arrangement financing is beginning to grow in Indonesia, especially in incentivizing energy efficiency. The split incentive problem identified in Indonesia shows that the currently designed program of incentives is still problematic for both providers and customers. This suggests that there are multiple alternatives to the incentives that are more suitable to assist in energy-efficiency implementation. Using case studies on retrofit financing for LED lamps in Indonesia, this study aimed to test the validity of those issues, which involved the process of energy decision-making within an organization. Triangulating the findings from case studies and questionnaire surveys, recommendations for future researchers, practitioners, and the government were made. The results indicated that retrofit financing in Indonesia is feasible. Financial metrics such as the analysis of discounted payback period, IRR, and NPV were used to further validate the result. The study also identified that the provider can use

Game Theory as a tool to analyze the costs and benefits of retrofit business decisions to tackle the split incentive problems. These findings could lead to improvement in strategies in considering the effectiveness of a firm's policy measures for delivering energy efficiency in the future.

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### INTRODUCTION

In Indonesia, potential in the energy-

efficiency sector is becoming increasingly important, where the increase in energy price continued to occur and became one of the most significant constraints in Indonesia's economic developments (Nafisah & Dwiningrum, 2016). The limited ability of Indonesia's state-owned electricity company to meet electricity needs is also another ongoing problem. One potential source of energy cost savings is the replacement of outdated equipment (conventional lamps using old technology required significantly larger amounts of energy to run) with new energy-efficient lighting equipment (LED lamps) (Husin et al., 2017). The act of replacing outdated equipment with new equipment with new technologies is often referred to as "retrofitting", which can potentially provide economic benefits; not only that, retrofitting is also an effort to improve Indonesia's energy usage efficiency.

The Indonesian government has not yet explored the potential energy savings cost. In contrast, the same potential energy savings cost has been explored and identified by most developed countries and becomes one of the strategies employed to address the challenges of energy security, climate change to mitigate carbon dioxide (CO<sub>2</sub>) emissions, and economic development (Organisation For Economic Co-operation And Development/International Energy Agency [OECD/IEA], 2007). Unfortunately, in Indonesia, most of those opportunities are still yet unrecognized, resulting in the energy-efficiency gap (O'Malley et al., 2003; Sathaye & Murtishaw, 2008) and hindering developments within the

energy-efficiency sector (Organisation For Economic Co-operation And Development/International Energy Agency [OECD/IEA], 2007). Many factors are keeping the savings potential unrecognized; one of them is the split incentives problems between providers and customers (O'Malley et al., 2003).

The split incentives problem is seen as a principal-agent (PA) problem, which refers to the problems that may arise when two parties are binding in a contract (Wright et al., 2001). PA problems in a retrofit were pervasive, disbursed, and complex; with only few empirical evidences presented in the literature, it can be categorized as the tip of the iceberg (International Energy Agency, 2007). PA problems are considered market barriers (International Energy Agency, 2007; Sæle et al., 2014). O'Malley et al. (2003) revealed that solutions to the PA problem could use to focus on the relationship between the customer as a principal and provider as an agent and to understand how that relationship influenced energy efficiency.

This study attempted to validate one of those barriers: a split incentive in PA problems by using case studies in retrofit financing for LED (light-emitting diodes) lamps in Indonesia, as the retrofitting was technically feasible and economically viable (ASEA Brown Boveri, 2013). Hence, the retrofit project was cost-effective. The retrofit's provider tried to offer the services that met customer needs. The providers made rational decisions on their service features, but sometime customers acted irrationally.

Due to lack of awareness, project acceptance rates among building owners vary across industrial and commercial sectors (Hoicka et al., 2014) and were generally very low, thus, the decision makers remained hesitant in investing their resources. This causes the acceptance of retrofitting projects in Indonesia to be fairly low, much lower than it should be considering the obvious economic advantages and technical feasibility. These are similar to those of other countries, where retrofitting projects remain an anomaly (Frankel et al., 2013; Fulton & Baker, 2012).

This study attempted to establish a framework for a critical comparative study; comparing and assessing the possibility of retrofit financial practices that involved decision-making within the organization.

## LITERATURE REVIEW

Several engineering-economic models have shown that investment in energy saving projects could provide a good financial return (Allcott & Greenstone, 2012). The LCC (life-cycle cost) model can be used as an economic method to evaluate investment costs that are taken into consideration for all costs arising from owning, operating, maintaining, and disposing of the assets (Mearig et al., 1999; Norris, 2001; Ruparathna et al., 2017). Realistic assumptions can be obtained from evaluating the performance over time of similar assets, conducted literature reviews, obtained information from manufacturers, vendors, contractors, and used average support and maintenance costs (Jafari & Valentin, 2017; Robinson, 1996).

## Split Incentive Problem as a Principal-Agent Problem

A split-incentive problem is defined as a circumstance in which the flow of investments and benefits is not properly rationed among the parties, thus impairing investment decisions (Navigant Consulting Inc, 2017). While the PA problem on retrofit financing in this study is used within the context of agency theory as a market barrier (O'Malley et al., 2003; Sathaye & Murtishaw, 2004). The theory demonstrates that principals often have different goals and information compared with an agent who supplies them with goods or services (Bird & Hernández, 2012).

There are two types of split incentive problems: ESA scheme incentives and ESPC scheme incentives. Under the ESA scheme, a retrofit provider (agent) buys and supplies all the components for energy-efficiency lamps. The percentage incentives are divided according to the lamp's life-cycle (five years). The high capital investment is quite risky, as a customer can default paying a portion of the energy incentives that belong to the provider. The second type of split incentive problem is an ESPC scheme in the temporal split incentive. In this situation, the provider has no idea how long it would receive the incentives because the incentives need to be done under the negotiations basis. The incentives must fulfill all the total investment cost related to energy-efficiency equipment.

A few published mathematical models were developed to describe the investment problem (Landeo & Spier, 2012; Milgrom

& Roberts, 1982; Prendergast, 1999). Prendergast (1999) proposed a simple linear model to describe the risen problem.

### **Signaling Profit**

In the PA model above, the payoff to the customer depends on the action taken by the retrofit provider. The customer is the first mover and chooses an incentive scheme to pay the provider depending on the observed signal. The provider then determines the optimal action to take, given the incentives, and then decides whether to accept the customer's offer, based on the expected payment and the subjective cost of performing the action. Upon commitment, the provider chooses an action that maximizes his/her payoff, and the customer observes the signal correlated to the provider's action; then he or she pays the provider according to the incentive scheme and receives a payoff dependent upon the signal (Gneezy et al., 2012; Riener & Traxler, 2011).

## **MATERIALS AND METHODS**

This study conducted the semi-structured questionnaire, interviews, and document analysis, adhering to the principles of grounded theory methodology (Corbin & Strauss, 1990; Glaser, 1999, 2016). The data for the game analysis were primarily obtained from the questionnaires and interviews. The probable decisions of the retrofit provider and customer under the two retrofit financing options were discussed. Below is the proposition as a part of our conceptual framework, which becomes a key task in designing our study.

**Proposition 1:** Retrofit financing in Indonesia was feasible to be implemented by provider XYZ. The sensitivity analysis and the scenario analysis using the LCC calculation were used to evaluate the energy saving based on the Indonesian current electricity rate.

**Proposition 2:** The strategy under Game Theory was suitable to use as a tool to analyze the costs and benefits of retrofit business decisions with a "mix strategy equilibria and reaction function" to tackle the split incentive problems.

A series of semi-structured questionnaires and interviews was conducted with the top-level people, such as the owners and general managers who were responsible for managing the retrofit project. The interview process helped the information obtained directly from the company's owner, corporate executives, and general managers in the projects involved. Secondary data (were obtained from industry data) and project documents (documents that were used to better understand the lighting industry and energy saving technology) determined the key points that should be addressed during the interviews and observations. This questionnaire allowed the authors to identify the key dimensions given, covered all aspects of the industry, the technical aspects, and managerial aspects.

For this study, the authors used a pseudo name that had been used to protect secrecy and only for the research's descriptive. The provider, XYZ, was one of the biggest suppliers of LED lamps in Jakarta. The second respondent was a manager of one

of the potential customers who directly engaged in the activities of the retrofit project. Energy-efficiency equipment and power saver utility costs (energy costs) were the main factors for which to measure the performance of an energy-efficiency retrofit. The provider, XYZ, computed the feasibility through the LCC analysis for both ESPC and ESA contracts. The current investment value (NPV), the rate of return (payback period), and the rate of profit required (hurdle rate) used analytical tools. The authors conducted semi-structured interviews with the respondents during the months of November 2016 to May 2017, via email and telephone.

## RESULTS AND DISCUSSIONS

### First Phase – Validate the Claims on the Energy Cost-Effective

Menicou et al. (2015) used the economic model to evaluate the financial impact over the investment horizon on Cyprus' residential buildings' energy retrofit potential. Mundaca and Neij (2009) investigated the numerous energy-economy models on energy efficiency policies to induce technological change. Their investigation focused on the residential sector within European countries; from the investigation, they revealed that the capital and operating costs were one of the factors required to achieve efficient technology and one of the most important factors that determined the consumer's decision in investing in retrofit projects. Following another investigation was conducted by Ruparathna et al. (2017) and Rysanek

and Choudhary (2013). They proposed a novel LCCA and economic benefit model approach for building energy retrofits. This study investigated the provider XYZ, a provider that utilized the energy economic model to analyze total cost, value, risk, and liquidity impact on investment opportunities with its resources. To successfully compete with other investment opportunities, energy-efficiency projects needed to be evaluated on the same basis with the others, and financial analysis was used to identify whether an investment reaches the required level of profitability.

The discounted interest rate was used as one of the main metrics of LCC analysis, which would depend on the inflation rate and risk-adjusted premium. The discounted interest rate with the specific amount of interest (%) above inflation was considered an appropriate value. The expected lifetime of LED lamp was a maximum of five years (or 15,000 hours). The following cost elements were selected for the LCC equation formulation: initial investment cost (IC); energy consumption cost (EC); and maintenance and replacement cost (MR). Based on Kumbaroglu and Madlener (2012) and Ruparathna et al. (2017), the change in LCC of a building due to energy retrofits can be calculated as  $LCC = IC + PV_{MR} - \Delta PV_{EC}$

To assess the feasibility of the project, this study used the same approaches and guidelines recommended by the EPA–Energy Star (United States Environmental Protection Agency, 1998): cash flow and customer's financial liquidity is evaluated first; then the rate of return (payback). The

hurdle rate was the accepted/rejected criteria to determine whether an investment passes the profitability test. If the IRR was higher than the required rate of return, the project was otherwise profitable investments. Required interest rate was the marginal cost of capital, adjusted for the risk of the project. The higher the cost of capital and risk, the higher the level of profit required. The EPA–Energy Star recommends using the required rate of return, which is 20% for the energy efficiency investments (United States Environmental Protection Agency, 1998).

LCC analysis for cash flow, NPV, payback period, and IRR, as stated in Table 1 and Table 2, was based on the sensitivity analysis for all variables used in this study. Contrary to Ruparathna et al. (2017), they used a fuzzy set theory-based approach for LCC analysis as the sole decision variable, which was used in multicriteria decision-making for the uncertainty factor consideration. Those uncertainty factors are included in energy, economy, environment, and nonmonetary units, which have been addressed through a Monte Carlo simulation, as most of NPV assessment is based on the static decision-making (Kumbaroglu & Madlener, 2012).

Two steps had been taken in this study; the first step was to assess the feasibility of the project by using the sensitivity analysis. It allowed the project to put into consideration how uncertainty in the output of an energy-efficiency savings model could apportion to different sources of the operation hours and electricity tariff into various levels (Ameli & Kammen, 2014). Importance

measures of each uncertain input variable on operation hours and electricity tariff variability provided a deeper understanding into the most effective way. The sensitivity analysis was investigated based on the key assumption, especially on electricity tariffs (IDR 1,467/kilowatt) and the possibility of electricity consumption (eight hours/day).

The second steps taken in this study involved the scenario analysis of retrofit's key assumptions, following the first step of sensitivity analysis. The findings of the scenario analysis in this case study provided new insights into the factors that influenced the decision of a provider to proceed with the retrofit project for energy-efficient lamps under an ESA or ESPC scheme.

The most useful information from the analysis was the range of values of discounted payback period (years), IRR, and NPV, which provided a snapshot of the investment riskiness. Under this analysis, the information can be useful in determining the inputs into an analysis that has the most effect on value.

As shown in the Table 1, under the scenario of ESA split incentives with discounted rates from 8% to 20%, the higher dominant incentive choice for the provider resides at the 50% to 70% split scheme area. On the contrary, the higher dominant incentives for customers resides at the 20% to 50% split scheme area. The overlapping and possibility to have tough negotiation and having a Nash equilibrium for both of provider and customer are in the 50% split area. The negotiations for both parties will not only be on splitting saving incentives

Table 1  
 ESA split incentives

Split Incentives	Discounted Rate %	8.0%	10.0%	12.0%	14.0%	16.0%	18.0%	20.0%	
70% (5Yrs)	Net present value (IDR)	182,291	167,910	154,906	143,124	132,430	122,707	113,851	
	Internal rate of return (%)	138.5%	134.2%	130.0%	125.9%	122.0%	118.3%	114.6%	
	Discounted payback period - Year(s)	<b>0.5184</b>	<b>0.4824</b>	<b>0.5229</b>	<b>0.5659</b>	<b>0.6116</b>	<b>0.6601</b>	<b>0.7115</b>	
60% (5Yrs)	Net present value (IDR)	130,208	143,923	132,776	122,677	113,511	105,177	97,587	
	Internal rate of return (%)	95.2%	113.0%	109.2%	105.6%	102.0%	98.6%	95.3%	
	Discounted payback period - Year(s)	<b>0.6221</b>	<b>0.5628</b>	<b>0.6100</b>	<b>0.6603</b>	<b>0.7136</b>	<b>0.7701</b>	<b>0.8300</b>	
50% (5Yrs)	Net present value (IDR)	130,208	119,936	110,647	102,231	94,593	87,648	81,322	
	Internal rate of return (%)	95.2%	91.7%	88.2%	84.9%	81.7%	78.7%	75.7%	
	Discounted payback period - Year(s)	<b>0.6221</b>	<b>0.6754</b>	<b>0.7321</b>	<b>0.7923</b>	<b>0.8563</b>	<b>0.9242</b>	<b>0.9960</b>	
40% (5Yrs)	Net present value (IDR)	104,166	95,949	88,518	81,785	75,674	70,118	65,058	
	Internal rate of return (%)	73.0%	69.9%	66.8%	63.9%	61.1%	58.4%	55.7%	
	Discounted payback period - Year(s)	<b>0.7776</b>	<b>0.8442</b>	<b>0.9151</b>	<b>0.9904</b>	<b>1.0704</b>	<b>1.1552</b>	<b>1.2450</b>	
30% (5Yrs)	Net present value (IDR)	78,125	71,962	66,388	61,339	56,756	52,589	48,793	
	Internal rate of return (%)	50.0%	47.3%	44.7%	42.1%	39.7%	37.3%	35.0%	
	Discounted payback period - Year(s)	<b>1.0368</b>	<b>1.1256</b>	<b>1.2201</b>	<b>1.3205</b>	<b>1.4272</b>	<b>1.5403</b>	<b>1.6601</b>	
0% (5Yrs)	Net present value (IDR)	52,083	47,974	44,259	40,892	37,837	35,059	32,529	
	Internal rate of return (%)	25.4%	23.2%	21.0%	18.8%	16.8%	14.8%	12.9%	
	Discounted payback period - Year(s)	<b>1.5552</b>	<b>1.6884</b>	<b>1.8301</b>	<b>1.9808</b>	<b>2.1408</b>	<b>2.3104</b>	<b>2.4901</b>	

but also will be focused on the discounted rate implied.

Meanwhile, under the scenario of ESPC split incentives as shown in the Table 2, the higher dominant incentives for a provider resides at 1 year to 1.25 years with full energy savings given to the provider and for the customer at 1.5 years to 2.5 years. The negotiation area and the possibility of having a Nash equilibrium are in the 1.25 years area. The same with ESA; one of the negotiation issues between both parties under ESPC will be focusing on the discounted rate.

Based on the result of the LCC model above, it could conclude that the profitability of this retrofit project passed the level of investment required (hurdle rate). Cash flow and financial liquidity of customers had an internal rate of return (discounted payback),

which were satisfactory, at below one year discounted payback period, with the discounted rate ranging from 8% to 20%. The payback period and rate of return on the project showed that the risk was quite low. The NPV showed that total net cash flow generated by the project throughout its five-year life of the ESA project and ESPC project were positive under the higher dominant incentives area. Meanwhile, the IRR exceeded the required interest rate (hurdle rate) of 20%, and it showed that the project was deemed profitable. It was in line with research findings from Gluch and Baumann (2004), Menicou et al. (2015), Nikolaidis et al. (2009), which revealed through NPV analysis that it was a reasonable and effective decision to retrofit existing buildings.

Table 2  
*ESPC split incentives*

Split Incentives	Discounted Rate %	8.0%	10.0%	12.0%	14.0%	16.0%	18.0%	20.0%
1 Year	Net present value (IDR)	89,333	86,236	83,250	80,368	77,586	74,898	72,300
	Internal rate of return (%)	110.3%	106.5%	102.8%	99.2%	95.8%	92.5%	89.3%
	Discounted payback period - Year(s)	<b>0.9067</b>	<b>0.9393</b>	<b>0.9730</b>	<b>1.0079</b>	<b>1.0440</b>	<b>1.0815</b>	<b>1.1203</b>
1.25 Years	Net present value (IDR)	209,762	205,245	200,913	196,756	192,764	188,928	185,238
	Internal rate of return (%)	131.3%	127.1%	123.1%	119.2%	115.4%	111.7%	108.2%
	Discounted payback period - Year(s)	<b>0.3862</b>	<b>0.3947</b>	<b>0.4032</b>	<b>0.4117</b>	<b>0.4202</b>	<b>0.4287</b>	<b>0.4373</b>
1.5 Years	Net present value (IDR)	249,191	243,253	237,576	232,144	226,942	221,957	217,175
	Internal rate of return (%)	149.3%	144.8%	140.4%	136.2%	132.1%	128.2%	124.4%
	Discounted payback period - Year(s)	<b>0.3251</b>	<b>0.3330</b>	<b>0.3409</b>	<b>0.3489</b>	<b>0.3569</b>	<b>0.3649</b>	<b>0.3730</b>
2 Years	Net present value (IDR)	328,049	319,269	310,902	302,920	295,298	288,016	281,050
	Internal rate of return (%)	179.9%	174.8%	169.9%	165.1%	160.6%	156.1%	151.9%
	Discounted payback period - Year(s)	<b>0.2469</b>	<b>0.2537</b>	<b>0.2605</b>	<b>0.2674</b>	<b>0.2743</b>	<b>0.2812</b>	<b>0.2882</b>
2.25 Years	Net present value (IDR)	364,558	353,822	343,637	333,962	324,762	316,006	307,665
	Internal rate of return (%)	184.3%	179.2%	174.2%	169.4%	164.7%	160.2%	155.9%
	Discounted payback period - Year(s)	<b>0.2222</b>	<b>0.2289</b>	<b>0.2357</b>	<b>0.2425</b>	<b>0.2494</b>	<b>0.2563</b>	<b>0.2633</b>
2.5 Years	Net present value (IDR)	401,066	388,375	376,371	365,004	354,226	343,997	334,279
	Internal rate of return (%)	188.6%	183.3%	178.3%	173.4%	168.7%	164.1%	159.7%
	Discounted payback period - Year(s)	<b>0.2020</b>	<b>0.2086</b>	<b>0.2152</b>	<b>0.2219</b>	<b>0.2287</b>	<b>0.2355</b>	<b>0.2423</b>

INCENTIVES HIGH IS DOMINANTS CLIENT CHOICES

INCENTIVES HIGH FOR BOTH PROVIDER & CLIENT (NASH EQUILIBRIUM)

INCENTIVES HIGH IS DOMINANTS PROVIDER CHOICES

The firm insights about the retrofit program were collected from the questionnaires sent to both parties. Below are the comments from the executives of the retrofit provider. The author asked: “Why does your company really want to enter the retrofit business? What kind of strategies to handle the customer’ financial liquidity?” The answers are as follows:

“We do not really want to enter the retrofit business, but from our previous observation, almost all business growths nowadays are supported by installment practices. In the case of the lighting industry, these installment methods are now made possible through the support given by the product itself (LEDs), where previously customers are only given with the sole option of using either fluorescent or HID. The savings given by energy consumption made it possible for us to introduce this retrofit payment option, as customers can gain benefit through their own investment savings”.

“We conduct auditing processes by examining their previous financial (bank) statements, with the minimum period of six months to one year.”

To validate the basic premise of the analysis, the provider must think of the investment payback period as a specific consideration whether it is better or worse. The author also asked: What are the requirements for the minimum payback year period for retrofit project handled by your company currently? In your view, how important are projects that aim to increase energy efficiency? How much is the fair basis for splitting the incentives saving between you and your customer? Do you have any kind of financial tools as your decision-making tools? The answers are as follows:

“Ideally the shorter the payment term is, the better for us. But in the case of installment, the one-year span is usually the minimum”.



“Very important. We need to reduce general heat output to increase overall cost efficiency”. “85% - 90%”.

“Logically, they are spending less money compared to the electricity bill they have to pay when they still using conventional lighting solution”.

“Yes, the financial tools were used, especially in the early assessing the financial liquidity as well as on the negotiation process on split-saving incentives”.

The same questions were sent to potential customer as the authors tried to obtain their insights into the retrofit financing program. The original questionnaire for customers was made in Bahasa, Indonesia, but it is translated into English for this study. Below is the illustration. The author further asked: How does your company see the retrofit program? How do you feel about the provider companies offering the current retrofit funding program?

“I think this program is good because it can help the owner of the company receive cost savings, provide better lighting and safety, and it also makes the appearance of more modern lights with investment funding that is not too significant at the beginning”.

“Quite a lot of options, each company offers the advantages of each program, it will be good for the customer because it has many options so that it can choose the best”.

To tackle the transaction cost, which most probably will arise, the author asked: If you are to take a retrofit financing program, what strategies do you use to resolve issues that may arise between your company and the retrofit financing provider? If you are

taking a retrofit financing program, what minimum requirements should the retrofit financing provider provide to you?

“A clear and detailed agreement at the beginning of the cooperation, to minimize constraints in the future”.

“Quality products, adequate product warranty, and reasonable price, supported by a bona fide company ensuring continuity of long-term cooperation”.

In addition, the author asked: How do you see the sharing of energy cost savings between a retrofit provider with your company? What do you think is a reasonable percentage of the austerity portion that retrofit providers should receive and how long will it last? The retrofit profit is calculated from the electrical savings that occur due to equipment replacement by the retrofit provider. What do you think is the reasonable rate of payback that retrofit providers should receive for their investments? Write your opinion in years or months.

“Win-win solution, fair enough, in accordance with each portion”.

“The split incentive given to provider is 20% (percentage of total savings)” and “for 3 years.”

“I think a reasonable payback period is about 12 - 18 months”.

Having the insights from both players into the retrofit business, the authors are confident and confirmed:

**Proposition 1:** Retrofit financing in Indonesia is feasible to be implemented by provider XYZ. The financial tools were used by both parties; the result of discounted

payback period, IRR, and NPV analysis show that retrofit financing is not only technically feasible but also economically viable under current energy cost regime, which is currently increasing over time.

### **Second Phase – Exploring the Principal Agent Problem Using the Game Theory Model**

By quantifying the principal–agent problem, as well as understanding and focusing on the principal–agent type (Organisation For Economic Co-operation And Development/ International Energy Agency [OECD/ IEA], 2007), it was possible to isolate the number of energy-efficiency projects from consumer’s decisions. As a strategy, Game Theory was used to understand decisions that providers make to affect customer decisions. To analyze this retrofit situation, the authors looked at the problem from the point of view of the provider and attempted to predict their choices using Game Theory to minimize the split incentive problems between the provider and their customer. The classic coordination game of “battle of the sexes” was chosen because both the customers and the providers needed to coordinate to install the energy-efficiency lamp under the retrofit financing but had no knowledge whether under ESA or ESPC.

A scenarios matrix shown in Figure 1 was created to predict a payoff matrix for the provider and customer as well as their available choices. It was the most challenging to set up a payoff matrix because the authors needed to figure out the payoff with a reasonable level of

accuracy. In this circumstance, the authors were playing the part of “provider”; hence, the authors did market research and made reasonable relative estimates of the payoffs that the provider might enjoy under each scenario. In this study, the authors asked the executives of the provider and the executives of the potential customer to determine their likelihood of choosing ESPC instead of ESA. To do this, the authors created a questionnaire survey that related to each scenario. The authors then determined provider and customer preferences by asking them. The author also asked that, if the provider or customer chose ESPC over ESA, how would they split the payoff amongst themselves. They then rated each scenario on a scale of 0 to 10.

The important insight obtained from the mixed strategy in Game Theory perspective was the provider focuses on the customer’s point of view putting its customers first, namely, “allocentrism,” which forced executives to look forward and reason backward, as they must put themselves into the customer’s shoes. To increase the value added to their retrofit project, they needed to add other benefits to their customer. Executives could make a profit by designing the game that was appropriate to the company as well as changing the game. Therefore, the authors concluded and confirmed:

**Proposition 2:** Executives could use Game Theory as a tool to analyze the costs and benefits of retrofit business decisions to tackle the split incentive problem. To understand this problem,

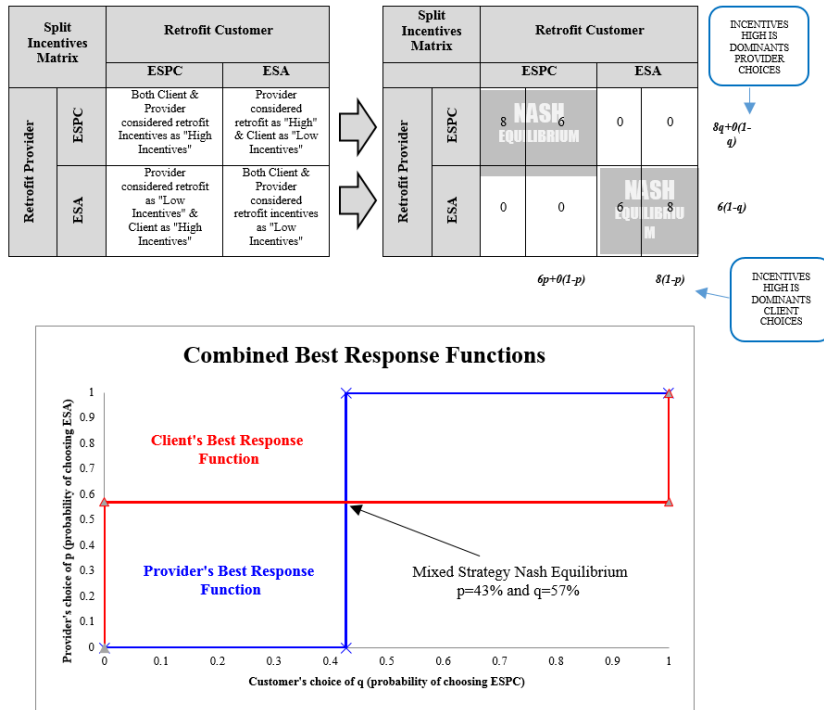


Figure 1. Best response strategy

executives needed to see the ramification of their retrofit programs by adopting allocentric perspectives. The important thing for executives to remember was to anticipate the customer’s moves in response to the initiatives implemented.

### CONCLUSIONS

This study helped to understand how both participants in this retrofit projects understood their value of the investment, agreed on a funding model, and analyzed project performance. In line with the result, both participants would focus on the processes to achieve the goals and objectives generated. Both participants

utilized a financial model approach in measuring the performance of the project to ensure the project meets its goals – whether financial or nonfinancial.

The LCC financial model was approached by measuring the performance of the project to ensure that it met its financial goals, as well as nonfinancial goals, such as resolving PA problems. Agreeing with the previous empirical literature, the energy retrofitting projects would benefit not only by reducing companies’ energy costs, but also by addressing energy-related issues, for instance energy security, climate change, and economic development.

The LCC model did not account for environmental benefits and social

impacts. The result focused on an economic perspective only. Thus, the findings could be useful as a practical LCC tool for the firm. In order to create a more comprehensive decision support tool for retrofitting projects, both environmental and social impact consideration had included within the traditional LCC model analysis approach. Combining engineering-economic models and incorporating socioeconomic considerations into the model would filled the gap in understanding economic barriers and noneconomic barriers to retrofit projects. Once this new approach is developed, the findings from an LCC model approach will not be the main factor for decision-making. This way, retrofit financing will consider the split incentive problem when participants are entering into contracts.

Game Theory helps one to understand the core idea behind the principal-agent problem, and it gives concrete reasons on why people make certain decisions. In this study, Game Theory was used to understand how provider's decisions would affect the customer's decision. The simple premise behind Game Theory in this study is that provider can calculate on the right decision to make before needing to make it. A provider's strategy in this study was categorized to be mixed because it applied some randomization to at least one of the moves, i.e., ESA or ESPC.

The Game Theory model is for simulating management situations and for providing a precise retrofit situation for provider action as in a management science. Critiques might arise from the

direct application of a game-theory model. In fact, the authors believed that, by having a good understanding of how its management worked, the providers would understand the repercussions of their action and how they should behave. Of course, customers had made rational decision-making on the retrofit based on the best course of action by examining all options (Nasip & Sudarmaji, 2018; Sudarmaji, 2017).

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