

Jatropha Biofuel and Power Generation Project in Cambodia - Executive Summary -

Unlike conventional biofuels, this proposed biofuel supply chain development maximizes the local benefits and provides a competitive biofuel for electric power generation without governmental subsidies. In a country where only 15 % of the population has an access to the electricity and the tariff is the highest in the Asian region, the proposed biofuel supply chain with an inedible vegetable oil gives an opportunity to provide stable and competitive electric tariffs in an industrial park-Phnom Penh Special Economic Zone (PPSEZ) in Cambodia. Since Cambodia fully depends on imported fossil fuels, this new effort may be able to contribute to its new energy strategy to improve its energy independency and develop a lower-carbon society in the future.

1. Purpose of the Project

The main objective of the project is production of a competitive biofuel for heavy fuel oil (HFO) generators in PPSEZ - a specially designed industrial park to host domestic and foreign manufacturing with total support of utilities and legal duties in Phnom Penh, Cambodia. Indirect but another primary objective of the project is income generation in rural communities by effectively using unused or unproductive land since the project requires substantial amount of inedible oil seed-*Jatropha curcus* (Jatropha) for the biofuel feedstock. (Fig.1)

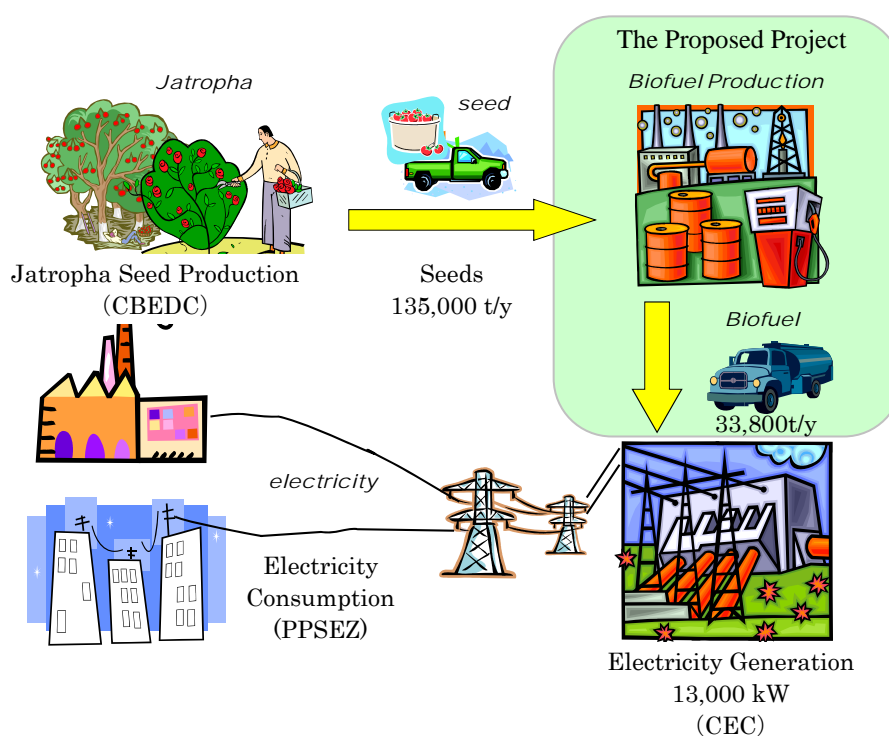


Fig. 1 The Concept of the Jatropha Biofuel and Power Generation Project

Due to the limitation of Cambodian national power company's (EDC: Electricite Du Cambodge) electric supply, most of the manufacturing in Cambodia have installed own captive generators powered by imported diesel or HFO. Since there is little public control of fuel price in Cambodia, the cost of the electricity is critical issue for any serious manufacturing in Cambodia. The proposed project aims to substitute a domestic competitive Jatropha based biofuel for the imported expensive and unstable HFO for the HFO generators. Due to the reduction of the HFO use, it is likely to contribute to Cambodian green house gas (GHG) emission reduction in one of primary GHG sources in Cambodia.

Although Cambodia has successfully recovered from the half centuries of chaotic era for last 10years, the benefit of the recovery has mostly improved the living standard of urban communities but little in rural communities. Since Cambodia depends on not only fuels but also basic commodities outside of the nation, any price in Cambodian has continuously increased accordance with the oil crisis even in rural communities. As a result, rural residents have been seeking for new income source other than conventional self-sufficient crop farming. The proposed project does not directly involved in biofuel feed production, but guarantees the long-term purchase from a subsidiary company (CBEDC: Cambodia Bio-Energy Development Corporation) of the proposed project's participant. Thus, the proposed project indirectly guarantees the new income source from Jatropha seed production for rural communities. In order to support participants' income generation, CBEDC provides necessary supports for Jatropha cultivation such as initial clearance, cultivation training, and initial planting of Jatropha. Since the economical productivity of Jatropha mono-farming may not be high enough for participants, CBEDC also aids participants to apply cash-crops' inter cropping to generate additional income. Therefore, the proposed project is likely to contribute to the rural communities' economies rather than other investment projects in Cambodia.

2. Contribution to Cambodia sustainable development

Within the Cambodian sustainable development policy, there are three key objectives; namely "Broad-based economic growth, social and cultural development, and sustainable use of natural resources." In order to prove the contribution of a proposed CDM project, four categories of sustainable development criteria are applied to quality the project. The four categories are 1) environmental protection and improvement, 2) enhancement of income and quality of life, 3) economic benefits, and 4) technology transfer.

Environmental protection and improvement; One of primary income sources in rural communities is fuel wood. Since Cambodia depends on fuel woods for residential energy use

throughout the nation, the impact of the deforestation has been substantial. The proposed project effectively uses such degraded land for seed production and provides income opportunities for such rural residents, which is likely to reduce the fuel wood cutting. The byproduct of the Jatropha PPO known as seed cake will be converted to artificial fuel wood and substitute the fuel woods in both rural and urban communities. Therefore, the proposed project is likely to improve the Cambodian natural environment.

Enhancement of income and quality of life; Since the rice production is the popular and high productive cash cropping in Cambodia, the rural communities in up-land area have hardly made enough income and sought for higher productive cash crops. The project indirectly provides opportunities for those up-land residents to increase their income through CBEDC's Jatropha and intercropping program. Unlike other biofuel seed exporting activities, the proposed project not only benefits on income generation but also better quality of life by accessing reasonable market through the CBEDC's farming network as well as continuous agricultural training.

Economic benefits; Fully dependency of imported fuels and other commodities are highly critical threat for Cambodian sustainable development. The proposed project provides an option to develop a renewable energy source by using the degraded or unproductive land in the nation. The improvement of rural communities' purchasing power is likely contributes to the regional economy. In addition, skill training for skilled and unskilled workers is likely to expand their opportunities to work in higher income jobs rather than self-sufficient farming only.

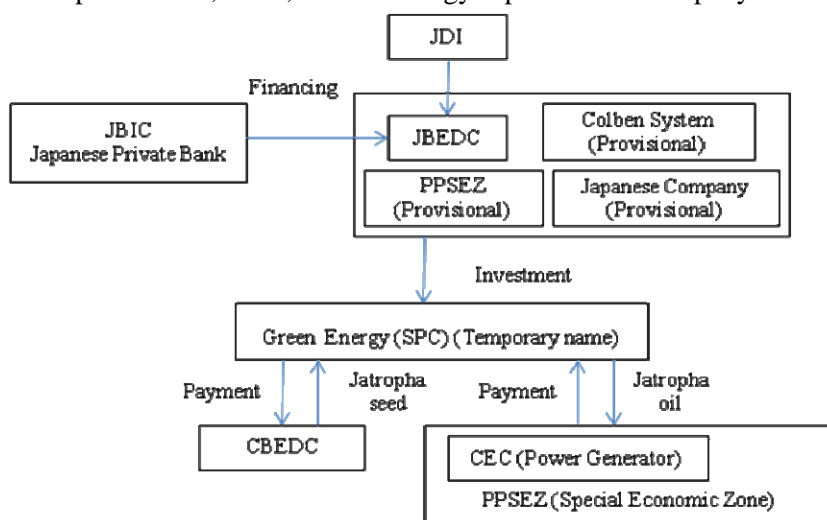
Technology transfer; In spite of its potentiality, agribusinesses have not prospered in Cambodia. The proposed project is one of the most potential fields of agribusinesses in Cambodia. Although the PPO technologies are not applicable in all developing countries, it is competitive and suitable for Cambodia. In addition, the transferred technologies are likely to contribute to the development of lower-carbon society development in Cambodia for the long-run.

3. Jatropha bio-energy and power generation project in Cambodia

3.1 Project overview

The proposed project aims to supply Jatropha biofuel for two additional HFO generators in PPSEZ with a total capacity of 13MW. This fuel switching contributes to GHG emission reduction and economical and reliable fuel supply realizing a competitive power supply for manufacturing in PPSEZ.

The proposed project establishes a special purpose company (SPC)-Green Energy Co., Ltd. (tentative name) responsible for Jatropha biofuel production and sales. The SPC is also responsible for the implementation, management, QA/QC, and administration of the CDM project. The SPC will be financed by a joint investment of four participants including; JDI, JBEDC (Japan Bio Energy Development Co., Ltd., a bio-energy specialized company established by JDI), PPSEZ (provisional), Colben System Pte Ltd. (CSL) a parent company of Colben Energy Cambodia Ltd. (CEC) operating a power generation in PPSEZ (provisional), and a Japanese company (provisional) willing to participate this CDM project.



Jatropha biofuel known as “Pure plant oil (PPO)” will be produced by oil extraction from Jatropha seeds and oil refining process in Kampong Speu state, a state next to Phnom Penh city. The biofuel feedstock supply will be performed entirely by CBEDC (Cambodia Bio-Energy Development Corporation), a subsidiary of JBEDC. 34,000 ton/year of Jatropha PPO is produced and transported to PPSEZ by fuel transporters. The PPO adapted generators in PPSEZ will substitute PPO for HFO.

Estimated GHG gas emission reduction from the proposed project is 2011: 489tCO_{2e}, 2012: 971tCO_{2e}, 2013: 7,589tCO_{2e}, 2014: 26,791tCO_{2e}, 2015: 52,645tCO_{2e}, 2016 to 2020: 68,235tCO_{2e}/year, and the reduction in total of 10years will be 429,657tCO_{2e}.

3.2 Biofuel feedstock supply

The success of this project requires 140,000tons of Jatropha seeds and 59,000ha of Jatropha plantation. CBEDC plans to collect Jatropha seeds by two contract farming schemes; (1) relatively large scale plantations and (2) small scale fencing and intercropping. The project is now at the stage of the practical productivities with a total of 20ha model farm. CBEDC has also improved the capacity of Jatropha production trainers to support plantation owners and contract farmers. CBEDC is planning to secure roughly 100,000 tons of seeds from a total of 41,000 ha large scale plantations and 40,000 tons from small scale fencing and intercropping with roughly 12,500 rural farmers.

1) Large scale plantation with the use of Economic Land Concessions (ELCs)

ELCs are the land use rights leased to domestic and international companies for agribusiness development in Cambodia. However, a large number of ELC holders have not succeeded in effective use of the lands. Utilizing those unused lands, large scale Jatropha plantations will be performed in ELCs contracting with those land holders. JDI has overcome the problems of small productivities of Jatropha by introducing cash crop intercropping. Cash crops' intercropping is a practical strategy to continuously attract ELC owners and secure the seed supply.

2) Small scale contract farming with fencing and intercropping in rural community

Small scale fence and intercropping based contract farming will be performed by small scale farmers scattered around the proposed project areas. This scheme is to produce Jatropha seeds by means of fencing cultivation along the hedge of the field, road strips and houses as well as small scale intercropping at their small unused land. CBEDC has been establishing seed collection systems in the rural communities with necessary training and competitive seed purchasing. Small intercropping farming will be introduced for their unused land with technical training provided by CBEDC's Jatropha and intercropping trainers as well as local NGOs.

The experimentation on intercropping plantation has seen a success in terms of harvests and interests shown by the farmers. Now the model farm folds successful 20ha of Jatropha plantation. Development of a several hundred plantation is planned by the middle of 2009 with an ELC holder.

3.3 Biofuel production and power generation

Normally, edible oil requires costly ester exchange reaction to produce biofuel. The proposed project will apply simplified refinery process technology - known as PPO or straight vegetable oil (SVO) technologies commonly used in Europe enabling the application of PPO directly to the slow engines such as agricultural engines and middle class generators. Wärtsilä, a power plant manufacturer has been developing PPO adapted generators and commercially produce PPO (or LBF: liquid biofuel) power generators with a technical support (Fig.2).

Applying this technology, Jatropha PPO production requires only oil extraction and simple refinery to meet the Wärtsilä's fuel specification. Comparing to conventional fatty acid metal ester (FAME) production, production cost of Jatropha PPO could be largely reduced not only by minimum investment for refineries but also the no need for substantial amount of energy, water,

and chemicals use for the FAME refining as well as treatment of FAME effluent and by products such as glycerin. These facts show the potential of competitive bio-fuel supply without subsidies from the government to compete fossil fuels (Fig.3).

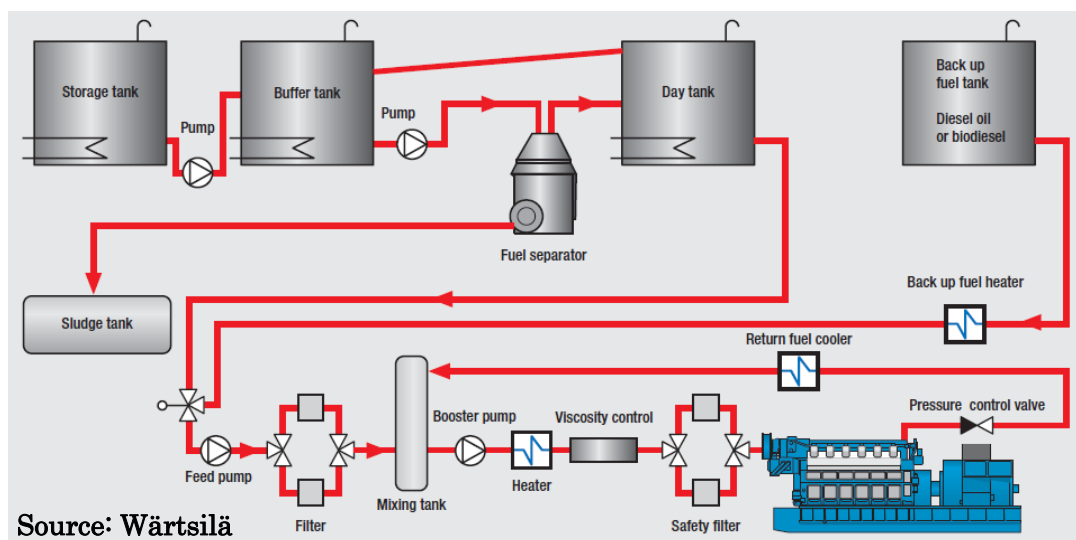


Fig. 2 Wärtsilä's Liquid Biofuel System for Its Generators

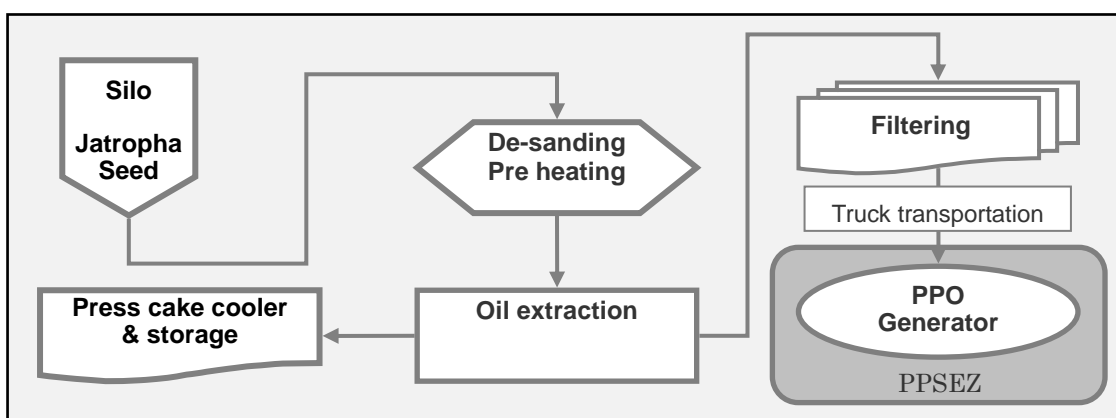


Fig. 3 PPO process and material flow diagram

The biofuel production is expected to start in 2011 with a gradual Jatropha seed production by 2016. Jatropha bio-fuel is expected to fully replace HFO by 2016.

4. Applicability of Clean Development Mechanism (CDM)

4.1 Type and Category of the Project

The project supplies electricity powered by Jatropha PPO solely in PPSEZ. The Jatropha PPO will be applied to two PPO adapted generators. The capacity of each generator is 6.5MW. According to the simplified modalities and procedures for small-scale CDM project activities,

this project falls under the following category and type of small scale project activities:

Type I: Renewable energy projects

Category A.: Electricity generation by the user/household

As this project applies renewable energy generation for own use and the capacity of the generators do not exceed 15MW, this project is eligible for small scale project type I.A.

4.2 Baseline emission

According to AMS-I.A., the energy baseline is the fuel consumption of the technology in use or that would have been used in the absence of the project activity to generate the equivalent quantity of energy. Followed by AMS-I.A. (Version 13) paragraph 7 (option2), the calculation bases on the consumption of fossil fuel in the absence of the project. Applying to this to the proposed project, baseline emission will be set by the continuous use of heavy fuel for electrification in PPSEZ. Annual energy baseline is calculated as the sum of annual electricity generation (MWh) and CO₂ emission based on the data from CEC, the independent power producer of PPSEZ. The baseline scenario emission is set by 72,180tCo₂e/year.

4.3 Project emission and leakage

The project emission was calculated by the following three components.

1) GHG emissions from an electricity consumption and a power generation

Electricity used in the oil processing plant will be purchased from the national grid in Kampong Speu, a proposed site for the plant. The emissions from electricity consumption for the Jatropha PPO production was calculated by the amount of electricity purchased (MWh) and the grid emission of electricity purchased (tCO₂e/MWh).

2) GHG emissions from the fossil fuel consumption for the power generation at PPSEZ

The emission from fossil fuel consumption are the sum of the amount of HFO used in the power plant (ton), calorific value of HFO (MJ/ton), and CO₂ emission from HFO. The HFO use in the power plant is estimated to continue for 5 years after the production of PPO because Jatropha seed supply will not meet the necessary biofuel production by then. As of the 6th year, a Jatropha seed production will be able to reach the full substitution of the HFO use.

3) GHG emissions from Jatropha seed and oil transportation

The emission from Jatropha seed transportation is calculated with the number of additional tank lorries used for oil transport in year, the average distance travelled for additional oil

transport in year (km), the calorific value of the transportation fuel (MJ/kg), the fuel density of the transportation fuel (kg/l), and the emission factor of the transportation fuel (tCO₂/MJ). The emission for Jatropha PPO transportation is smaller than the present emission for HFO transportation from Sihanoukville port to PPSEZ. Therefore, the emission for PPO transportation is omitted.

Leakage includes GHG emission from the fertilizer application and the clearance of lands. According to the baseline emission and the project emission, the GHG emission reduction is estimated as shown below (Table. 1).

Table. 1 The reduction of GHG emission

	BE _{CO₂,y} (tCO ₂ e)	PE _{CO₂,y} (tCO ₂ e)	LCO _{2,y} (tCO ₂ e)	ER _{CO₂,y} (tCO ₂ e)
2011	72,180	71,678	13	489
2012	72,180	70,508	702	971
2013	72,180	55,887	8,704	7,589
2014	72,180	31,748	13,641	26,791
2015	72,180	3,945	15,590	52,645
2016-20	72,180/y	3,945/y	0/y	68,235/y
Total for the crediting period	721,800	253,491	38,650	429,657

4.4 Monitoring Plan

The project boundary physically includes the Jatropha PPO processing plant and power units where Jatropha PPO is consumed for electricity generation. The required data for Jatropha PPO processing plant is collected by the SPC. The required data regarding to power generation is collected by CEC and reported to the SPC. The leakages regarding Jatropha seed production and collection will be monitored and reported by CBEDC to the SPC. The monitoring plan will be given by the SPC to each responsible participant. The SPC will be responsible for the quality assurance and control of the monitoring data.

4.5 Crediting Period

Including the maturity of Jatropha plants and the construction of an oil processing plant the duration of the project will be at least 15 years. Due to uncertainty of the biofuel business development in Cambodia, we concluded to apply 10 years-one time crediting period starting from 2011.

5. Feasibility of the Proposed Project

5.1 Financing

Cambodian private banks have few experiences in long term loans and commonly used short-term/revolving loan accompanies with interests 4 to 5 times higher than a Japanese development bank (eg. JBIC). Considering this proposed project, the feasibility was analyzed with the possible loan provided by Japan Bank for International Cooperation (JBIC) since the majority of the SPC will be Japanese stakeholders.

JBIC has an investment loan scheme for Japanese entities to support foreign investments. The JBIC's loan will be implemented with a public and private cooperate financing. According to a major Japanese bank, a fundamental condition to consider this project is the full security of loan capital by insurance or public guarantee. Nippon export and investment insurance (NEXI) has full cover (100%) insurance for CDM project. A possible combination of NEXI oversea investment insurance, private loan, and JBIC's loan may be available with competitive interest rates.

5.2 Economic Analysis

From economic analysis based on initial cost of the project and the amount of GHG emission reduction, calculated Internal Rate of Return (IRR) and the Return on Investment (ROI) is shown below (Table 3). In the case of no certified emission reduction (CER), IRR will be 14.8% with ROI of 8 years, whereas in the case of CER of 15 US\$/tCO_{2e}, IRR will be 17.4% with ROI of 7years. This result shows the project largely increases its profitability with the certification of the carbon credit.

Table. 2 Estimated Internal Rate of Return & Return on Investment

Price of CER	Internal Rate of Return (IRR)	Return On Investment (ROI)
No CER	14.8%	8 years
5 US\$/t CO _{2e}	15.7%	8 years
10 US\$/t CO _{2e}	16.7%	7 years
15 US\$/t CO _{2e}	17.4%	7 years
20 US\$/t CO _{2e}	18.2%	7 years
25 US\$/t CO _{2e}	18.9%	7 years
30 US\$/t CO _{2e}	19.7%	7 years

For a financial sensitivity analysis, IRRs were calculated with 4 key factors in the range of ±25% from the baseline. The elements are (1) the price of CER, (2) the sales price of Jatropha PPO, (3) purchasing price of Jatropha seed, and (4) investment and operating

capital. Since the cost of the feedstock is the majority of the project's expense, the buying price of Jatropha seeds largely affects IRRs. The sales price of the Jatropha PPO is also a significant factor as same impact as seed buy. On the contrary, the CER price and investment costs are relatively minimal impacts on the proposed project's IRRs.

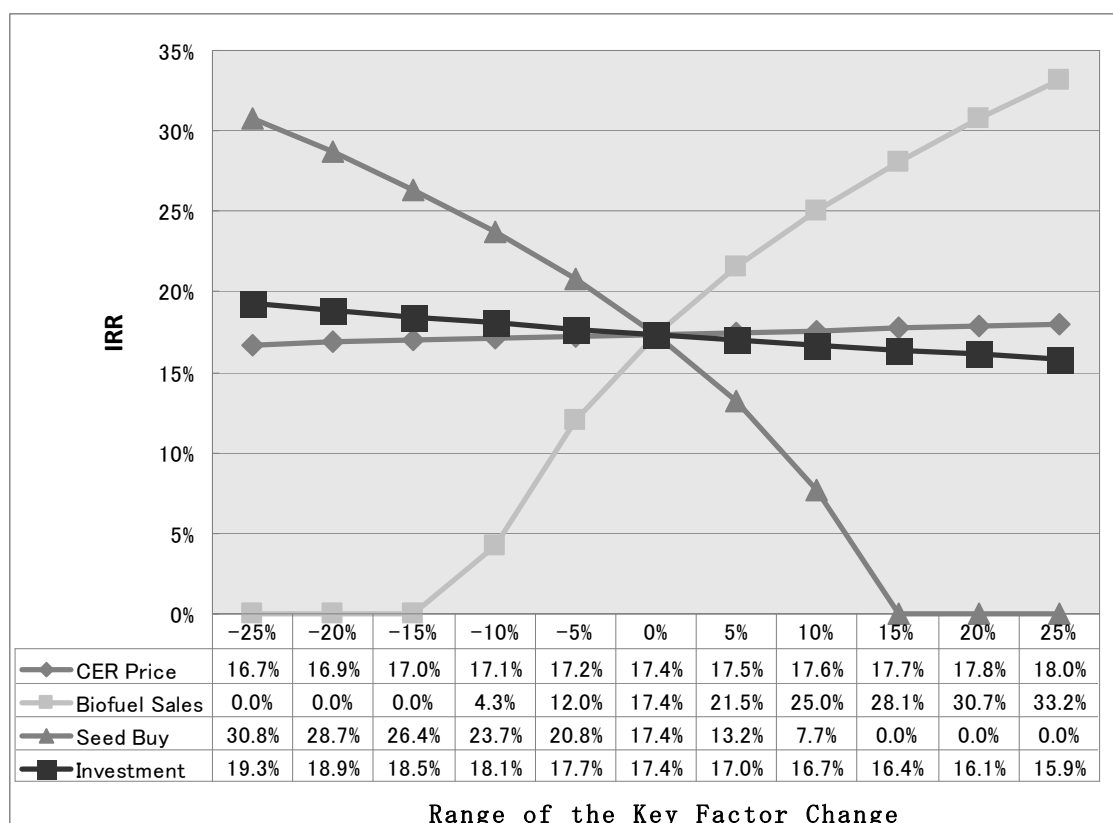


Fig. 4 Sensitivity Analysis of the Project's IRR

6. Consideration of Co-benefit CDM in Cambodia

Sulfur in fossil fuel products transforms into sulfuric acid, such as sulfur-dioxide commonly known as a serious air pollutant. Increasing use of gasoline and HFO for transportation and power generation would be a potential serious issue for human health in Cambodia.

For the existing generators, HFO use in CEC contains around 2% of sulfur (up to 3.5%). On the other hand, up to 0.13% of sulfur content has been found and reported in some scientific study. Therefore, the use of Jatropha PPO may be able to reduce the sulfur-dioxide emission down to one twenty fifth (1/25) compared to HFO.

However, due to a lack of fuel test and engine test for this study, we concluded no indicators and their criteria are proposed this time.