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## Article

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International Journal of Energy Economics and Policy

## Provided in Cooperation with:

International Journal of Energy Economics and Policy (IJEEP)

*Reference:* Saria, Mustika/Wan Mohamed, Wan Mazlina et. al. (2022). The optimization using electric ground support equipment in aviation industry. In: International Journal of Energy Economics and Policy 12 (1), S. 401 - 406.

<https://econjournals.com/index.php/ijEEP/article/download/11711/6626>.

doi:10.32479/ijEEP.11711.

This Version is available at:

<http://hdl.handle.net/11159/8589>

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# The Optimization Using Electric Ground Support Equipment in Aviation Industry

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Received: 13 August 2021

Accepted: 22 December 2021

DOI: <https://doi.org/10.32479/ijee.11711>

## ABSTRACT

An airport is one of the country's infrastructures that provides air transportation services. In providing its services, to ensure aircraft safety, airports must conform to a set of international technical operating standards and planned operating procedures. In addition, airports also have a social responsibility to prevent pollution and support eco green. Therefore, this study aims to conduct a benefit cost analysis using electric ground support equipment in aviation industry, both for using e-GSE using diesel and using e-GSE using electricity. The method used in this research is the Benefit Cost Ratio method. Based on the research results, it shows that the use of e-GSE using both diesel and electricity is feasible because it has a net present value (NPV) value of more than 0. However, when compared with the assumption of 25 years of use, the use of e-GSE using diesel is considered more profitable than using electricity.

**Keywords:** Benefit Cost Analysis, Electric Ground Support Equipment

**JEL Classifications:** P41, P28, P43

## 1. INTRODUCTION

Airport operators are responsible for expanding their facilities and services in order to play a role in the aviation industry. Among the responsibilities are terminal services, ground services facilities, and passenger baggage and cargo movement between the airfield and terminals. Airport operators are also in responsible to manage the airport's commercial facilities, ground transportation from and to the airport, parking infrastructure, surface access links, and other related factors outside the confines of an airport terminal (Graham, 2018).

Airports are the source of emissions that have a negative impact on the environment, and these emissions are produced by activities both inside and outside the airport. As a result, living near airports may pose a significant risk to people's health. Airport operators are becoming more aware of how the construction, operation, maintenance, and other activities at airport facilities can contribute to the industry's overall impacts on climate change (Giuffre and Grana, 2011).

Ground handling is a service provided by airlines that assists in the crusade of aircraft while on land by using a few tools to measure in motorized and non-motorized modes for the purposes of accuracy, safety, security, and cost-effectiveness. Ground handling costs a lot of money to complete work for the necessary operational coordination with all parties involved with the movement of tools for land. Such tools would require diesel fuel, which has been used by all ground handling vehicles, referred to as ground support equipment (GSE). Ground handling, which is frequently associated with the operation of ground support equipment in airports, plays a role in emission reduction efforts. Efforts are currently being made by ground handling companies to plan for and gradually implement electric vehicles or renewable fuels (Aerospace, 2012).

The total scope of ground handling work includes nine standard service units: passenger handling, baggage handling, cargo and mail handling, aircraft handling and loading, load control, air side management and safety, aircraft movement control,

standard ground handling agreement, and airport handling. GSE requirements (International Air Transport Association, 2014).

GSE research has yet to be as extensive as that of aircraft operations, fleets, and emissions. GSE's current data is regarded as untrustworthy, limited, and out of date. In order to adequately plan and maintain the increasing demands for excellent air quality service, the FAA requires accurate GSE data. Air quality can only be improved if airports implement effective strategies to reduce surface emissions (Airport Cooperative Research Program, 2012a).

The airside ground operation contributes significantly to emissions. Taxiing is one of the most emission-intensive modes of transportation during departure (Bubalo et al., 2017). The emission can dangered the human health (Jaafar et al., 2018), such as increase vascular dementia (Li et al., 2019), degradation of lung function and many health problem (Suhaimi et al., 2020)

The level of polluted engine exhaust emissions, unsafe air pollution (HAPs), and greenhouse gases (GHGs) in every piece of GSE (with the exception of electric GSE) is heavily dependent on the engine size, which is typically measured in brake horsepower (BHP), the type of fuel (diesel or gasoline), the engine's on and run time, and load factors. The load factors are defined as the average energy demand ratio on the equipment required to reach the maximum (peak load) of the equipment (Airport Cooperative Research Program, 2012b). The air pollution mainly come form vehicles, and the concertation of NO and CO reduce significantly during COVID-19 pandemic, when less vehicles are on the road (Talib et al., 2021).

The use of eco fuels by air transport companies is one of the Indonesian government's efforts to reduce air pollution. Government regulations must provide for the provision and use of eco fuels to support renewable energy, as required by Government Regulation No. 26, 2008. The usage of gas as energy source can reduce the carbon emission (Farabi et al., 2019). Enforcement is also aimed at assisting air transport for aircraft on the ground, also known as ground handling. The government also should have roadmap on future energy, either renewable or non-renewable energy, such as the use of wind and water energy, biomass, biodiesel, biogas, and other sources (Faizah and Husaeni, 2018).

Reduced carbon emissions from air transportation and airport operations have been included in Indonesia's Action Plans through the implementation of renewable energy for airport facilities and the ongoing implementation of eco-airport programs. As a result, in 2017, DGCA Indonesia issued a DG Decree establishing an emissions reduction program for airport operations. The incorporation of the degree requires airports in Indonesia to report to the Director General on a regular basis their carbon emissions, including both emissions production and reduction. The decree is aimed at measuring the effectiveness of eco-airport program implementation and monitoring the emissions reduction progress as stipulated in Indonesian State Action Plans (Indonesia Team, 2018).

Furthermore, the APEC annual meeting stated that the Indonesian government has committed to mitigating climate change and reducing greenhouse gas emissions. Presidential Decree 71/2011 on the implementation of the greenhouse gas inventory, and the energy and transportation sectors contribute 0.056 percent (Samad, 2013). While a green eco vehicle costs slightly more than a conventional car, the return on investment is immediate. Fuel, insurance, and maintenance costs are drastically reduced, saving a significant amount of money in the long run. Proper care and responsible driving are required when operating any type of vehicle, and eco vehicles are designed to have a minimal impact on the engine (Kuttner, 2015).

While a green eco vehicle costs slightly more than a conventional car, the return on investment is immediate. Fuel, insurance, and maintenance costs are drastically reduced, saving a significant amount of money in the long run. Proper care and responsible driving are required when operating any type of vehicle, and eco vehicles are designed to have a minimal impact on the engine.

## 2. METHODOLOGY

This study makes use of secondary data from a third party, specifically data from a ground handling company and an aviation ground support equipment company. The information includes the cost of electrical GSE, diesel GSE, and operation. Cost Benefit Analyst in this research is applied to transportation investments, project scenario assumptions should be aware that these frequently have infinite lifetimes. Energy 25 years, Water and Environment 30 years, Railways 30 years, Roads 25 years, Ports and Airports 25 years, Telecommunications 15 years, Industry 10 years, Other Services 15 years are typical project lifetimes for public investment projects (Jones et al., 2014).

This research using Nett Present Value (NPV). NPV is the difference between the value of incoming cash flows and the value of cash outflows over a period of time. The feasibility can implement if the NPV value is greater than zero.

The formula to calculate is:

$$NPV = \sum_{t=0}^n \frac{(Benefit - Cost)_t}{(1 + r)^t}$$

Where:

r = discount rate

t = year

n = analytic horizon (in year).

## 3. RESULT AND DISCUSSION

Cost benefit analysis (CBA) has been widely accustomed support the decision-making process in transport. The consideration of non-economic variables into the analysis, such as noise, accidents, air pollution and so on, has been troublesome for the application of CBA (Tudela et al., 2006).

CBA is a formal process for evaluating a project that evolved from the economic constructs of consumer surplus and externality. It then moved into a formal regulated process based upon work by economists and government agencies and is now required by many entities for project approval, seeking the efficient allocation of resources. It is a decision making tool that is one of the most widely accepted and applied methods for project appraisal for large-scale infrastructure investments in the public sector because it provides many benefits including, a model of rationality, creating, evaluating and comparing alternatives including different scales for the alternatives, monetizing the costs and benefits and guiding decision makers (Jones et al., 2014).

When CBA is applied to investments in transportation, project scenario assumptions should be aware that these often have infinite lifetimes (Lee, 2002). Typical project lifetimes for public investment projects are Energy 25 years, Water and Environment 30 years, Railways 30 years, Roads 25 years, Ports and Airports 25 years, Telecommunications 15 years, Industry 10 years, Other Services 15 years (Jones et al., 2014).

Table 1 describe the investment of ground support equipment by diesel fuel and electric fuel which electric fuel more expensive than diesel fuel. In calculating the investment feasibility with NPV analysis several aspects are considered, namely income, expenses, net profit, discount rate, and the economic age of the product. The revenue used in this calculation represents the total operating income of Ground handling Company in various segments. The Ground Handling and AHAN segments contributed the highest to Ground handling Company operating income, which was around 76.9%. Meanwhile, the cargo warehousing and non-ground handling segments contributed 17.9% and 5.2% respectively. Therefore, investment in the GSE is indeed needed since this segment gives the highest income earned. Refers to an annual report published in 2013-2017, the financial statements show that yearly income increases by around 10% with the result that Company revenue is projected to increase every year by 10%. The Company expenditure on operational activities will also be estimated to increase by 10% annually. Projected increases in income and spending are also made because of the possibility of inflation every year (Table 2).

In the company's profit and loss projection, revenue will be reduced by total expenses to find out the gross profit. After that, gross profit will also be subject to income tax of the business entity

**Table 1: Investment of Ground Support Equipment (GSE) in US Dollars**

No	Name Of GSE	Diesel Fuel	Electric
1	Pax Boarding Stair	26,000	40,285
2	Belt Conveyor Loader	25,000	40,000
3	Baggage Towing Tractor	32,500	42,000
4	High Lift Loader	23,000	37,000
5	Forklift	45,000	59,000
6	Push Back/ATT Wide Body	116,000	130,000
7	Ground Power Unit 180 KVA	32,000	44,000
	Total Invest	299,500	392,285

Sources: Ground handling company

to find the net profit obtained, in accordance with government regulations that business income tax above 100 million rupiahs is 25% of the total taxable income (Gapura Angkasa, 2017). After calculating the profit and loss projection, it can be seen that the cash flow is mainly to see the comparison of the total cash in and cash out during the economic life of the tool for 20-25 years. This cash flow will facilitate us in calculating the parameters of investment feasibility. This analysis aims to compare the feasibility of investment for GSE products that use diesel fuel and electricity. Each product is assumed can be uses for 20 until 25 years with a discount rate of 3%. The results of the analysis can be seen as follows.

From the Table 3 above can be known there are no significant differences from investing in GSE Product that uses diesel fuel either electricity. There is no NPV value below 0, so investing in a product that uses diesel fuel or electricity is feasible. Investing products with useful life 25 years is the best choice since there is a huge gap between NPV value that assumed uses for 25 years and 20 years. The GSE product that uses diesel fuel has the highest NPV score than others. Investing in a GSE product that uses diesel fuel for 25 years can be more profitable than NPV for a product that uses electricity.

### 3.1. The Feasibility in using Diesel Fuel for 25 and 20 Years

In the use of e-GSE using diesel from 2017 to 2041, the prediction of 25 years of investing in diesel for profit and loss still has a margin of around 10% annually. In 2041, the net profit will reach USD 32,259,701.

In addition, the cash flow of diesel use for 25 years every year from 2017 to 2041 the expenditure will increase by 10% annually

**Table 2: The Income projection of Ground Handling Company 2017 to 2041**

No	Year	Income/ year (USD)	No	Year	Income/ year (USD)
1	2017	120,133,309	14	2030	414,732,763
2	2018	132,146,639	15	2031	456,206,040
3	2019	145,361,303	16	2032	501,826,643
4	2020	159,897,434	17	2033	552,009,308
5	2021	175,887,177	18	2034	607,210,239
6	2022	193,475,895	19	2035	667,931,262
7	2023	212,823,484	20	2036	734,724,389
8	2024	234,105,833	21	2037	808,196,828
9	2025	257,516,416	22	2038	889,016,510
10	2026	283,268,058	23	2039	977,918,161
11	2027	311,594,863	24	2040	1,075,709,977
12	2028	342,754,350	25	2041	1,183,280,975
13	2029	377,029,785			

Sources : Ground Handling Company annual report, 2017 ( Process by the author)

**Table 3: The Projection feasibility cost in using diesel versus electricity (USD)**

The GSE Product uses diesel fuel		The GSE Product uses electricity	
25 years	20 years	25 years	20 years
196,296,805	128,476,615	196,268,647	128,452,391

**Table 4: Net Present Value Using Diesel Fuel in 25 Years**

Year	Interest	PV	Year	Interest	PV	NPV
1	0.9709	4,251,164	15	0.6419	7,991,328	196,296,805
2	0.9426	3,407,201	16	0.6232	8,533,629	
3	0.9151	3,637,481	17	0.605	9,112,128	
4	0.8885	3,883,857	18	0.5874	9,731,049	
5	0.8626	4,146,673	19	0.5703	10,391,859	
6	0.8375	4,427,610	20	0.5537	11,097,652	
7	0.8131	4,727,502	21	0.5375	11,849,612	
8	0.7894	5,047,731	22	0.5219	12,655,642	
9	0.7664	5,389,808	23	0.5067	13,515,153	
10	0.7441	5,755,387	24	0.4919	14,431,845	
11	0.7224	6,145,433	25	0.4776	15,412,955	
12	0.7014	6,562,625				
13	0.681	7,008,113				
14	0.6611	7,482,864				
Total PV					196,596,305	

(Table 4). In 2041, the new cash flows will cost USD 32,271,681. The NPV value for investment in GSE products using diesel fuel assumes a useful life of 25 years (Gapura Angkasa, 2017).

NPV: Total PV- Total Investment  
: Usd 196,596,305 – Usd 299,500  
: Usd 196,296,805

Meanwhile, for the prediction of using e-GSE using diesel with an assumption of 20 years from 2017 to 2036, investing in diesel for profit and loss still has a margin of around 10% annually. In 2036, the net profit will reach USD 20,030,736 (Table 5). And cash flow from the use of diesel for 20 years every year from 2017 to 2041 the expenditure will increase by 10% every year. By 2036, the new cash flows will cost USD 20,045,711 (Gapura Angkasa, 2017).

NPV: Total PV- Total Investment  
: Usd 128,767,115 – Usd 299,500  
: Usd 128,467,615

Meanwhile, for the prediction of using e-GSE using electricity with an assumption of 20 years from 2017 to 2036, investing in diesel for profit and loss still has a margin of around 10% annually. In 2036, the net profit will reach USD 20,030,736. And cash flow from the use of electricity for 20 years every year from 2017 to 2041 the expenditure will increase by 10% every year. By 2036, the new cash flows will cost USD 20,050,351.

### 3.2. The Feasibility in using Electric Fuel for 25 and 20 Years

The use of e-GSE uses electric fuel from 2017 to 2041, the prediction that in 25 years investing in electric fuel for profit and loss still has a margin of around 10% annually. In 2041, net profit will reach USD 32,259,701 (Gapura Angkasa, 2017).

Meanwhile, cash flow from electricity use for 25 years each year from 2017 to 2041 expenditure will increase 10% annually. By 2041, the net cash flow will cost USD 32,275,393 (Tables 6 and 7).

NPV: TotalPV- Total Investment  
: Usd 196,660,932 – Usd 392,285

: Usd 196,268,647  
NPV: Total PV- Total Investment  
: Usd 128,844,676 – Usd 392,285  
: Usd 128,452,391

There is some research literature on transportation using the BCA method. This method is used to predict time savings, the impact of the number of accidents, and reduction of noise disturbances. CBA is also used for transportation policy, which deals with environmental consequences such as CO<sub>2</sub> emissions. In transportation studies using CBA, important issues discussed are time savings, increased traffic safety, other advantages of improving railroads. In several countries since 1981 the discount rate has decreased from 8% to 3.5% in 2012. It is quite difficult to select a discount value according to the project because it will be used as a parameter to calculate the present and future net value (Andersson et al., 2018).

## 4. DISCUSSION

From the finding, investing the electric ground support equipment in the ground handling company in Indonesia is feasible, even though investing a GSE product that uses diesel fuel for 25 years can be more profitable than uses electricity. This is not very surprising because Indonesia just began with the electricity vehicle and somehow less power in electricity. Also, Indonesia does not have a nuclear power. But with the support from the Indonesia government, Indonesia have willingness to start built electric vehicle industry and does not depend on fossil fuel.

Indonesia President announced with new regulation Number 55/2019 to support the electric vehicle. Indonesia is committed to encouraging the acceleration of the battery-based motor vehicle program to support the realization and realization of reducing greenhouse gas emissions, increasing energy efficiency, energy security, and energy conservation in the transportation sector and realizing clean energy, clean air and environmentally friendly, and encouraging acceleration. Indonesia open up new and exciting business opportunities from the upstream to downstream supply chain that is needed to build the EV industry forward.



**Table 5: Net Present Value Using Diesel Fuel in 20 Years**

Years	Interest	PV	Years	Interest	PV	NPV
1	0.9709	4,254,072	11	0.7224	6,147,597	128,467,615
2	0.9426	3,410,024	12	0.7014	6,564,726	
3	0.9151	3,640,222	13	0.681	7,010,153	
4	0.8885	3,886,518	14	0.6611	7,484,844	
5	0.8626	4,149,256	15	0.6419	7,993,251	
6	0.8375	4,430,119	16	0.6232	8,535,495	
7	0.8131	4,729,938	17	0.605	9,113,940	
8	0.7894	5,050,096	18	0.5874	9,732,808	
9	0.7664	5,392,104	19	0.5703	10,385,026	
10	0.7441	5,757,616	20	0.5537	11,099,310	
				Total PV	128,767,115	

**Table 6: Net Present Value in Investing Electric Fuel For 25 Years**

Years	Interest	PV	Years	Interest	PV	NPV
1	0.9709	4,254,768	14	0.6611	7,485,318	196,268,647
2	0.9426	3,410,700	15	0.6419	7,993,711	
3	0.9151	3,640,877	16	0.6232	8,535,942	
4	0.8885	3,887,155	17	0.605	9,114,373	
5	0.8626	4,149,874	18	0.5874	9,733,229	
6	0.8375	4,430,719	19	0.5703	10,393,975	
7	0.8131	4,730,520	20	0.5537	11,099,707	
8	0.7894	5,050,661	21	0.5375	11,851,607	
9	0.7664	5,392,653	22	0.5219	12,657,579	
10	0.7441	5,758,149	23	0.5067	13,517,034	
11	0.7224	6,148,115	24	0.4919	14,433,670	
12	0.7014	6,565,229	25	0.4776	15,414,728	
13	0.681	7,010,641			Total PV	196,660,932

**Table 7: NPV for investing in The GSE product uses electricity (20 years)**

Years	Interest	PV	Years	Interest	PV	NPV
1	0.9709	4,258,576.48	12	0.7014	6,567,980.16	128,452,391
2	0.9426	3,414,397.19	13	0.681	7,013,312.03	
3	0.9151	3,644,466.88	14	0.6611	7,487,911.29	
4	0.8885	3,890,640.30	15	0.6419	7,996,228.91	
5	0.8626	4,153,257.94	16	0.6232	8,538,386.37	
6	0.8375	4,434,004.04	17	0.605	9,116,746.79	
7	0.8131	4,733,709.71	18	0.5874	9,735,533.43	
8	0.7894	5,053,757.87	19	0.5703	10,396,212.33	
9	0.7664	5,395,659.21	20	0.5537	11,101,879.14	
10	0.7441	5,761,067.93			Total PV	128,844,676
11	0.7224	6,150,948.37				

One of the airports that has become a role model for environmental sustainability is an airport in Sweden and the Scandinavian region. Swedish airports strive to minimize harmful emissions and slow down the global warming process. Swedish airports have the goal of achieving fossil oil free air transportation by 2045. Apart from airlines, the emission contributor in the aviation industry is GSE which is used to handle and serve aircraft. GSE operators are working to switch to equipment that reduces carbon. GSE investment is made with a combination of electricity, biogas and fossil fuel free (Airside International, 2019).

Meanwhile, investment in vehicles and equipment involves cooperation with several equipment providers and providing incentives for ground operators to use environmentally friendly vehicles. Another airport in Europe that is practicing zero emission

in ground operations is Stuttgart airport, Germany. This airport prioritizes vehicles that consume the most fossil fuels and occupy the largest emissions to be diverted to electric. The equipment are passenger bus, luggage tractor, and ground power unit.

Meanwhile, in Asia, there are Singapore and Hong Kong which have standards in supporting reducing emissions due to the use of GSE. Singapore, through the Changi Airport Group, collaborates with ground handling to reduce emissions at the airport by diverting the use of a fossil baggage tractor to an electric baggage tractor. Currently, there are about 80 GSE machines operating at Changi Airport that use electric power.

Since 2017 Changi has started using electric GSE, and the result is that Changi can reduce 1000 tons of carbon dioxide emissions.

An example of how GSE can reduce carbon is the Ground Power Unit (GPU) tool to reduce about 90% CO<sub>2</sub> and 95% NO<sub>x</sub>.

Currently, the new eco-airport concept has been developed in five airports in Indonesia, namely Soekarno Hatta (Jakarta), Juanda (Surabaya), Ngurah Rai (Denpasar), Hang Nadim (Batam), dan Sultan Mahmud Badarudin II (Palembang).

## 5. CONCLUSION

The aim of this research is to conduct the feasibility study of the usage e GSE for ground support equipment in aviation industry using benefit cost analysis. Based on the results of the study, it shows that the use of e-GSE using both diesel and electricity is feasible because it has an NPV value of more than 0, so investing in products that use diesel or electricity is possible. Investments in products with a useful life of 25 years are the best choice because there is a large gap between the NPV values that are assumed to be used for 25 years and 20 years. GSE products that use diesel have the highest NPV value compared to other products. Investing in GSE products that use diesel for 25 years can be more profitable than NPV for products that use electricity.

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