Integrated Economy and Society: Diversity, Creativity, and Technology
16–18 May 2018
Naples • Italy

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TIIM

Management, Knowledge and Learning
International Conference 2018
Technology, Innovation and Industrial Management

LIFE CYCLE COST ANALYSIS IN DESIGNING A SUSTAINABLE COMMERCIAL KITCHEN

Kurniadi Setiono,
Faculty of Engineering, Kasetsart University, Thailand

Sasivimol Meeampol,
Faculty of Business Administration, Kasetsart University, Thailand
fbusbsas@ku.ac.th

Pornthep Anussornnitisarn,
Faculty of Engineering, Kasetsart University, Thailand
fengpta@ku.ac.th

Abstract:
The purpose to use life cycle cost analysis (LCCA) in designing a commercial kitchen is to estimate the overall costs of commercial kitchen equipments, to select type of equipments, and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function. The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs (LCC). The first and most challenging task of an LCCA or any economic evaluation method is to determine the economic effects of alternative designs of an equipment or equipment system and to quantify these effects and express them in Thai Baht amounts. As the tables below illustrate of equipment's life in 5 years for both economic and quality equipments. The present value of maintenance, operations, and utility costs are greater as the initial project costs. There is always an issue during the selection of type, number, and quality of commercial kitchen equipments between owners and operators since they always have different concerns. The owners want to have the initial investment cost as low as possible and the tendency is that they buy the number, type, and quality of commercial kitchen equipments at the lowest purchase cost. On the other hand, the operator wants to have flexibility during the operation but it still maintains high quality of service so they request to have a full set of quality equipments to make the job done quickly and professionally. Cost effectiveness is a very important aspect in designing a commercial kitchen during the selection and arrangement of the equipments in the kitchen and how they are related to other mechanical, electrical and plumbing (MEP) supporting facilities. To improve the cost-effectiveness of commercial kitchens, it is necessary to invest in designs and systems with improved long-term performance. As a result, LCCA need to consider not only the initial costs of an equipment but also long-term costs, including utilities, operations, and maintenance as a whole package in a certain period of time.

Keywords: life cycle cost analysis, cost-effectiveness, long-term costs, equipment

1. INTRODUCTION

Cost effectiveness is a very important aspect in designing a commercial kitchen during the selection and arrangement of the equipment in the kitchen and how they are related to other mechanical, electrical and plumbing (MEP) supporting facilities. To improve the cost-effectiveness of commercial kitchens, it is necessary to invest in designs and systems with improved long-term performance. We need to consider not only the initial costs of an equipment but also long-term costs, including utilities, operations, and maintenance as a whole package in a certain period of time.
One of the tools that can be used to mediate the investment cost, operation cost, and profit earned is to use Life Cycle Cost Analysis (LCCA) where all the costs involved in operating the food and beverage facility are broken down and analyzed based on the concept that will be applied.
Life cycle cost analysis (LCCA) is a method of evaluating the cost-effectiveness of project design decisions and it has a process of evaluating the economic performance of a facility over its entire life. LCCA balances initial monetary investment with the long-term expense of owning and operating the facility. It takes into account all costs of acquiring, operating, and disposing of an equipment or equipment system. LCCA is especially useful when project alternatives that fulfill the same performance

requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings.
LCCA can be applied to any capital investment decision in which relatively higher initial costs are traded for reduced future cost obligations. It is particularly suitable for the evaluation of equipment design alternatives that satisfy a required level of equipment performance but may have different initial investment costs, different operating and maintenance and repair costs, and possibly different lives. LCCA provides a significantly better assessment of the long-term cost-effectiveness of a project than alternative economic methods that focus only on first costs or on operating-related costs in the short run.
By analyzing the total costs including the implications, we are able to determine type, number, and quality of commercial kitchen equipment in the beginning of design process which is agreed by investor and operator so designing kitchen can be done effectively and within budget and schedule. This Life Cycle Cost Analysis (LCCA) is also able to give a better understanding in resolving the issue to determine the location of MEP supporting facilities which is always a dilemma either to have it close to kitchen for operation cost effectiveness or far from kitchen because of architectural design consideration.

2. LITERATURE REVIEW

2.1 Industry Survey on Energy

Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily increasing energy consumption. Energy efficiency in the commercial kitchen is very important since it uses 5 times more energy per square foot than the rest of the building. Energy efficiency is the goal to reduce the amount of energy required to provide products and services. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process or by application of commonly accepted methods to reduce energy losses.

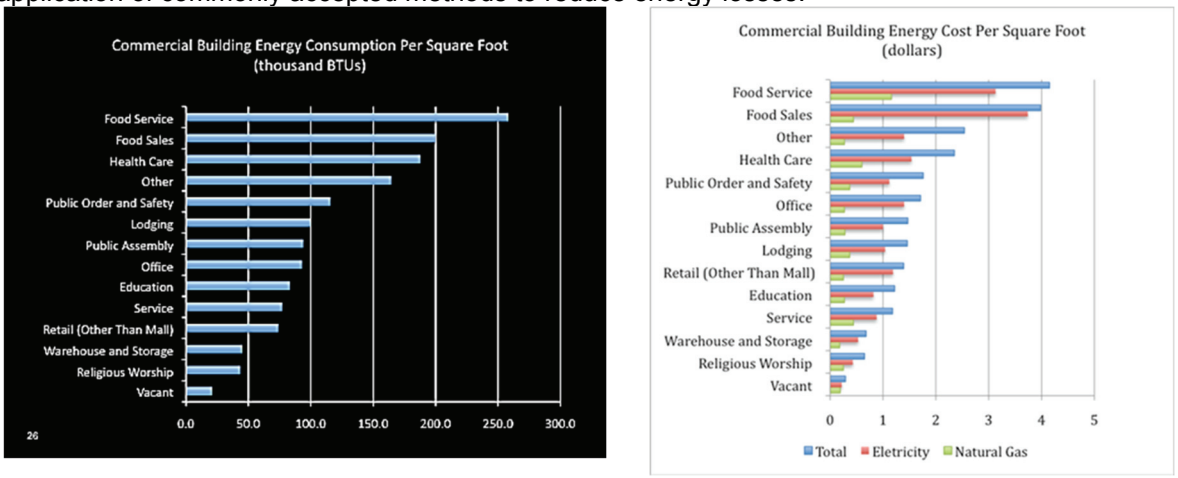


Figure 1: Businesses that use the most energy (Thousands BTUs) and Commercial Building Energy Cost Per Square Foot (Dollars), from National Action Plan for Energy Efficiency (2008).

In a food processing facility, high energy demand, underutilization of facility capacity, and underutilization of individual unit operations may cause unnecessary energy consumption. In order to facilitate appropriate energy reduction within a large chain of commercial kitchens, energy use must be translated into a form that can be compared between kitchens to enable operators to assess how they are improving and to allow rapid identification of facilities which require action. Energy cost in a hotel requires 5%-6% of total expenses and 28%-32% out of it comes from a commercial kitchen which shows that energy cost is a big cost in operating kitchen equipment.

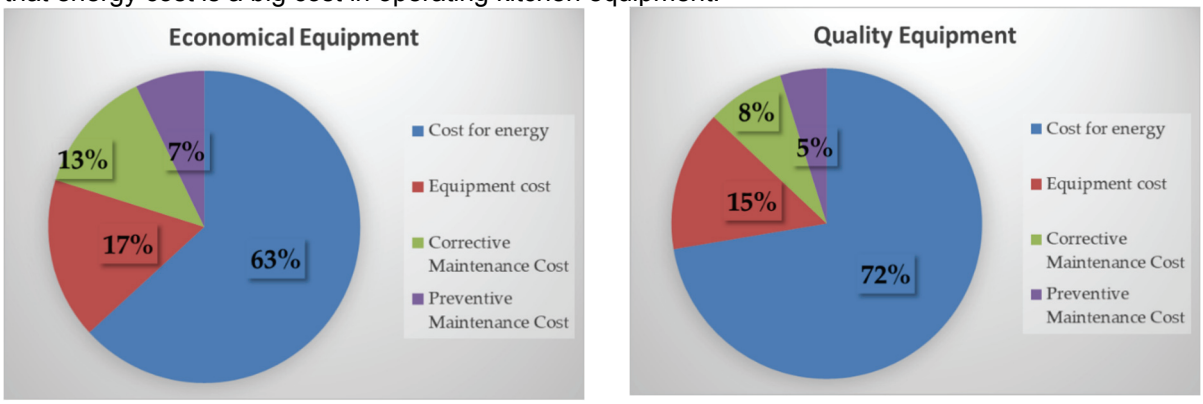


Figure 2: Total Cost of Economical and Quality Equipment in 10 Years

2.2 Selection Variety of Commercial Kitchen Equipment

The global food service equipment market size was estimated at USD 31.64 billion in 2018 and is expected to expand at a CAGR of 5.0% during the forecast period. It is now a mandatory requirement that an environmental performance assessment be carried out on all public sector construction projects resulting the demand to apply green building certification that encourages the development of commercial kitchen equipment toward energy efficient products resulting varieties of options in the market which is categorized in the following group:

No	Description	Cooking Equipment Grouping by Performance			
		Group 1 (Premium)	Group 2 (Quality)	Group 3 (Economical)	Group 4 (Regular)
1	Work Top Thickness	3 mm	2 mm	2 mm	1.5 mm
2	Structure	Stailess Steel solid wall construction	Stailess Steel solid Frame construction	Stailess Steel solid Frame construction	Frame Construction using mixed materials or lower grade stainless steel
3	Leg Thickness	1.2 mm	1.2 mm	1 mm	1 mm
4	Hardware Materials	Premium quality and using 316 SS for food contact including working surface and 304 SS for others	Good quality and using 316 SS for food contact and 304 SS for others	Regular quality of 304 SS	Mixed 304 SS and other materials
5	Performance and precision	Premium quality and high performance	Good quality and good performance	Good quality and regular performance	Regular quality and limited performance
6	Craftmanship	Superior	Very good	Good	Rough
7	Coving on Cabinet	Coving is applied at all surface joints	Coving is applied on the bottom part	Limited coving applied	There is no coving applied
8	Projected Year of Use	10 to 15	7 to 10	5 to 7	3 to 5
9	Initial cost	Highest	15%-20% lower than Group 1	15%-20% lower than Group 2	15%-20% lower than Group 3
10	Energy efficiency	Most efficient	10%-15% higher than Group 1	10%-15% higher than Group 2	10%-15% higher than Group 3
11	Yearly Ratio of Maintenance cost to Initial Cost	4% - 5%	4% - 5%	7% - 8%	8% - 9%
12	Application	Extra heavy duty	Heavy duty	Medium duty	Light duty

Table 1: Equipment Group by Performance

3. PRELIMINARY CASE STUDY

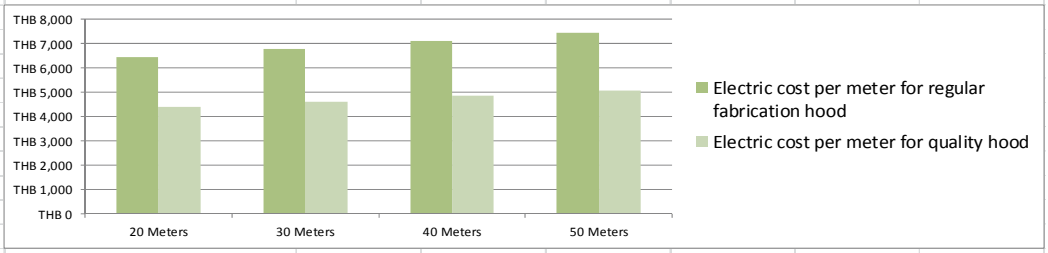
The purpose to use LCCA in designing a commercial kitchen is to estimate the overall costs of commercial kitchen equipment, to select type of equipment, and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function. The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs (LCC). The first and most challenging task of an LCCA or any economic evaluation method is to determine the economic effects of alternative designs of an equipment or equipment system and to quantify these effects and express them in Thai Baht amounts. As the tables below illustrate of equipment's life in 5 years for both economic and quality equipment. The present value of maintenance, operations, and utility costs are greater as the initial project costs. Decisions about equipment-related investments typically involve a great deal of uncertainty about their costs and potential savings. Performing an LCCA greatly increases the likelihood of choosing a project that saves money in the long run. Yet, there may still be some uncertainty associated with the LCC results. LCCAs are usually performed early in the design process when only estimates of costs and savings are available, rather than certain Thai Baht amounts. Uncertainty in input values means that actual outcomes may differ from estimated outcomes. There are techniques for estimating the cost of choosing the "wrong" project alternative. Deterministic techniques, such as sensitivity analysis or breakeven analysis, are easily done without requiring additional resources or information. They produce a single-point estimate of how uncertain input data affect the analysis outcome. Probabilistic techniques, on the other hand, quantify risk exposure by deriving probabilities of achieving different values of economic worth from probability distributions for input values that are uncertain. However, they have greater informational and technical requirements than do deterministic techniques. Whether one or the other technique is chosen depends on factors such as the size of the project, its importance, and the resources available. Since sensitivity analysis and break-even analysis are two approaches that are simple to perform, they should be part of every LCCA.

3.1 Exhaust Hood: Wall Mounted VS Island Mounted VS Distance to Fan

1) Wall mounted exhaust hood requires less air flow requirement than island type
2) The closer distance from the exhaust hood to the fan, the less electric is required.
3) Quality hood requires 30% less air flow rate than regular one so the utility system is cheaper as well, such as: cost for ducting, filters, and fan.
4) Operating the quality hood is cheaper for the regular one for a long term. It also cuts down the cost for air conditioning since it requires less heat load.

1	Heat level of cooking equipment * *ASHRAE Standard 154*			Single Wall Mounted	Single Island Hood	Remarks
	a. Heavy duty: grill, burner, kwali range, fryer			400	600	SFM per linear foot
	b. Medium duty: hot top, griddle, gas boiling pan			300	500	SFM per linear foot
	c. Light duty: oven, induction cooker, electric boiling pan			200	400	SFM per linear foot
2	Quality hood requires 30% less air flow rate than the regular one					
3	Every additional distance of 10 meters will raise 5% of fan capacity					
4	Number of days/year	365.25	Days			
5	Operation hour	10	Hr/day			
6	Cost of electric	3.9	THB/KWH			
This table is based on:		**30**	**Meters Length of Cooking Block and 1.2 Meter Depth**			

	Electric Cost	Wall Mounted Hood					
		Hood Air Flow Requirement (CFM)	Fan Electric Requirement (KW)	Cost for energy per Year Based on Distance from Hood to Fan			
				20 Meters	30 Meters	40 Meters	50 Meters
a	Electric cost per meter for regular fabrication hood	38,000	13.56	THB 6,439	THB 6,761	THB 7,099	THB 7,454
b	Electric cost per meter for quality hood	30,400	9.25	THB 4,392	THB 4,612	THB 4,842	THB 5,084



	Electric Cost	Island Mounted Hood					
		Hood Air Flow Requirement (CFM)	Fan Electric Requirement (KW)	Cost for energy per Year in Distance from Hood to Fan			
				20 Meters	30 Meters	40 Meters	50 Meters
a	Electric cost per meter for regular fabrication hood	57,000	20.34	THB 9,658	THB 10,141	THB 10,648	THB 11,180
b	Electric cost per meter for quality hood	45,600	13.875	THB 6,588	THB 6,918	THB 7,263	THB 7,627

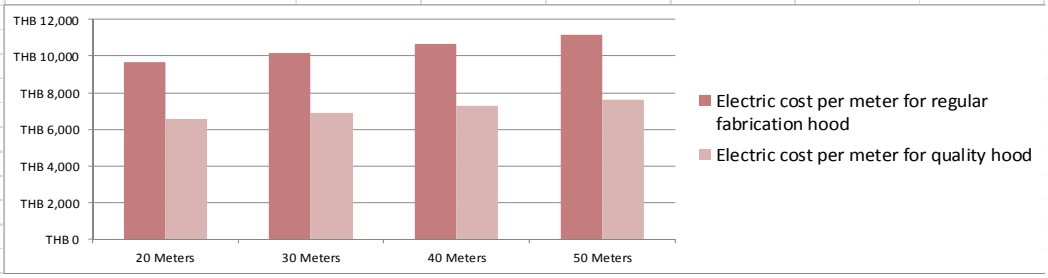


Figure 3: Distance Implications comparison for regular and quality hoods

3.2 Condensing Unit: Distance Implications

1) Refrigeration system runs 24 hours a day.
2) The closer the distance from refrigeration unit to condensing unit (CDU), the less capacity CDU will be required. As the result, it will request less electric so it will get cheaper electric cost.
3) Operating chiller is cheaper than freezer

1	Standard outdoor condensing unit is designed for 10 meters away from the indoor one					
2	Every additional distance of 5 meters will raise 7% of compressor capacity					
3	Operation hour				24	Hr/day
4	Number of day per year				365.25	Days
5	Cost of electric				3.9	THB/KWH
6	Electric requirement for 1 chiller CDU {(2.2 m (L) x 2.4 m (D) x 2.5 m (H)}				3.2	KW
7	Electric requirement for 1 freezer CDU {(2.2 m (L) x 2.4 m (D) x 2.5 m (H)}				3.7	KW

No	Cold Room	Electric (KW)	Electric cost per year in distance from Cold Room to Outdoor CDU				
			10 Meters	20 Meters	30 Meters	40 Meters	50 Meters
1	Cold room chiller	3.50	THB 109,399.68	THB 117,057.66	THB 124,715.64	THB 132,373.61	THB 140,031.59
2	Cold room freezer	4.60	THB 126,493.38	THB 135,347.92	THB 144,202.45	THB 153,056.99	THB 161,911.53

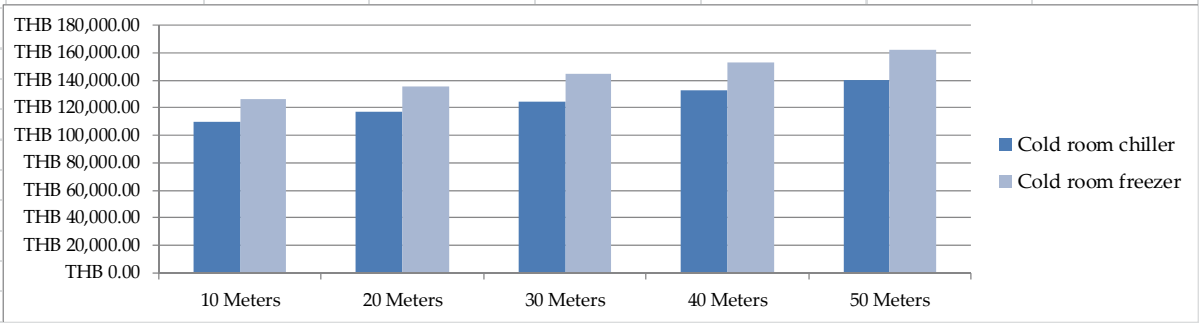


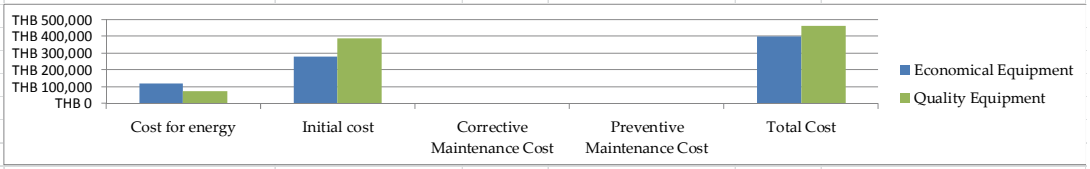
Figure 4: Distance Implications comparison for condensing unit chiller and freezer

3.3 Cooking Equipment: Quality VS Economical Equipments

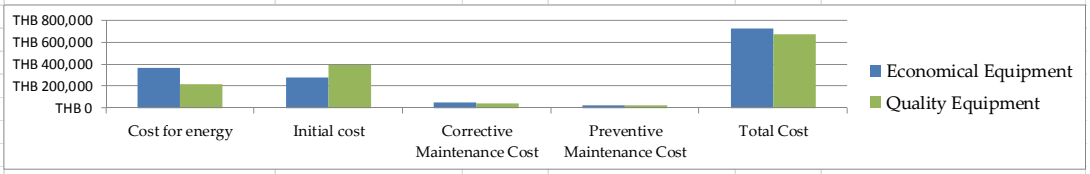
1) If the investment for short period of time, the total cost for economical equipments is cheaper than the quality one
2) If the investment for long period of time, the total cost for economical equipments is more expensive than the quality one
3) Economical equipment requires more corrective and preventive maintenance costs. The possibility to experience the lost opportunity is higher due to the down time.
4) Quality equipment can be used up to 10 year or even more depending on maintenance

Note:	*Example - Electric Combi Oven 10 GN 1/1 Pan*			
a	Number of days/year	365.25	Days	
b	Operation hour	10	Hr/day	
c	Connected Load	17	kW	
d	Energy Running for economical equipments	50%		
e	Energy Running for quality equipments	30%	Quality equipment ≈ Energy Star equipment ≈ Green equipment	
f	Cost of electric	3.9	THB/KWH	

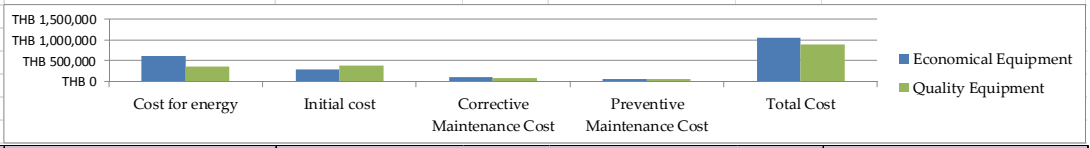
No	Description	1 Year Cost				Remarks
		Economical Equipment		Quality Equipment		
1	Cost for energy	THB 121,080	30.19%	THB 72,648	15.70%	
2	Initial cost	THB 280,000	69.81%	THB 390,000	84.30%	
3	Corrective Maintenance Cost	THB 0	0.00%	THB 0	0.00%	It is still in 1 year warranty
4	Preventive Maintenance Cost	THB 0	0.00%	THB 0	0.00%	It is still in 1 year warranty
	Total Cost	**THB 401,080**		**THB 462,648**		



No	Description	3 Year Cost				Remarks
		Economical Equipment		Quality Equipment		
1	Cost for energy	THB 363,241	50.20%	THB 217,945	32.44%	
2	Initial cost	THB 280,000	38.70%	THB 390,000	58.04%	
3	Corrective Maintenance Cost	THB 51,660	7.14%	THB 39,975	5.95%	
4	Preventive Maintenance Cost	THB 28,700	3.97%	THB 23,985	3.57%	
	Total Cost	**THB 723,601**		**THB 671,905**		



No	Description	5 Year Cost				Remarks
		Economical Equipment		Quality Equipment		
1	Cost for energy	THB 605,402	57.42%	THB 363,241	40.92%	
2	Initial cost	THB 280,000	26.56%	THB 390,000	43.93%	
3	Corrective Maintenance Cost	THB 108,615	10.30%	THB 84,047	9.47%	
4	Preventive Maintenance Cost	THB 60,342	5.72%	THB 50,428	5.68%	
	Total Cost	**THB 1,054,359**		**THB 887,717**		



No	Description	10 Year Cost				Remarks
		Economical Equipment		Quality Equipment		
1	Cost for energy	THB 1,210,804	62.42%	THB 726,482	49.74%	
2	Initial cost	THB 560,000	28.87%	THB 390,000	26.70%	Ecomical equipment has to be changed after 5 years
3	Corrective Maintenance Cost	THB 108,615	5.60%	THB 215,018	14.72%	
4	Preventive Maintenance Cost	THB 60,342	3.11%	THB 129,011	8.83%	
	Total Cost	**THB 1,939,761**		**THB 1,460,511**		

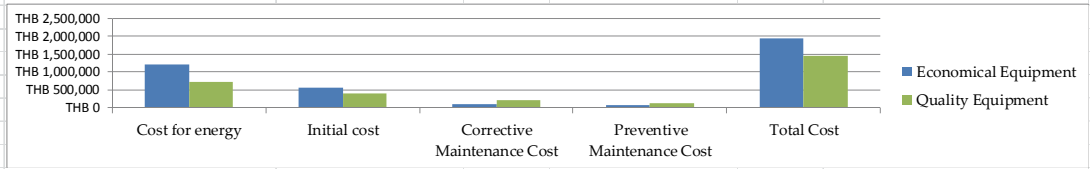


Figure 5: Total operation cost of economical and quality equipments in 1, 3, 5 and 10 years

4. CONCLUSION

Conducting a life cycle cost analysis during design process is to analyze the actual data to gain the most profitable investment plan since the operation of a sustainable commercial kitchen has to be functional, energy efficient, and financially viable. Life cycle cost analysis will impact the financial of decision and strategy during selecting equipment and conducting the space planning depending on how long they will operate the food service facility, size of facility, type of facility, and revenue generated.

Owner will be able more accurately to calculate the initial cost, break-even point, return of investment, and profit in better picture. Operators will be able to determine the number, type, and grade of equipment including the required space to operate a commercial kitchen with a better financial understanding in their mind while achieving high quality of service. When the equipment and location have been determined at early stage of design process, it will speed up the whole design process significantly and give assurance that the commercial kitchen will be financially feasible to operate.

It will take more efforts to study the possibilities and financial simulations at the early stage of design process but it will save a lot of time and efforts in the whole design process. It will mediate the conflicts of selecting commercial kitchen equipment and space planning by calculating the initial investments, revenue, operation cost, and profit based on the agreed food and beverage concepts in the beginning of project. A commercial kitchen must have the capacity to endure the operational requirements to produce the quality products effectively in order to generate revenue and maintain the operation cost efficiently. So it will be sustainable by balancing the requirements of layout planning, energy efficiency, and the direction of investment and put them in harmony.

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