REDUCING CARBON EMISSION BY VISITING PATIENTS ACTIVITIES IN A SCREENING CENTRE THROUGH CLEANER PRODUCTION STRATEGIES

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ABSTRACT

In this work, a cleaner production strategy was conducted in HSC (Heart, Stroke, Cancer) Medical Center, located in Ampang, Kuala Lumpur with an objective to propose improvement opportunities to reduce carbon emission generated from resources consumption and waste generated from medical treatment activities. For this purpose, a detailed cleaner production audit was conducted to identify key entities that contributed to the generation of carbon emission in the case studied medical center. The boundary of study covers activities related with medical treatment of patients. The stage involved is from the moment patient start to register at until they finished all their examination tests. The CP audit conducted focusing on waste minimization, energy efficiency as well as water minimization. Since global warming issues is currently a hot topic which affect the ecosystem and become a threat to nature living, this study has been justified through CO_2 equivalent emission before and after CP implementation. The objective of this study is to generate potential cleaner production options that can be suited best for the premise. Total carbon foot print quantity will be judged along the study based on the costing analysis is carried out. Health issue related to the process emission has also been included in this study as it constitutes part of the major process. Method of data collection has been obtaining through past records, observation and feedback from personnel. CP option were then generated and evaluated to identify the feasibility of implementation. Cleaner production audit findings shows that 207 tonnes of CO_2 was generated annually from overall activities in the hospital where the main contributors of the carbon emission generation were electricity, water consumption and waste management, with percentage of contribution of 83.5%, 15%, 1.70% respectively. Subsequently nine CP option were generated. Focusing on electricity, water consumption, and waste management. The implementation of the options can save up to RM3660 per month. Furthermore, the implementation also is expected to improve other

aspect, such as reduction in safety risk aspect, increase in productivity, and uphold the company image. The results from this work show that CP strategies can be implemented in many sectors, including service sectors such as hospital to reduce carbon emission on a national level as well as on a scale of global uptakes.

ABSTRACT

Dalam bidang kerja ini, strategi pengeluaran yang lebih bersih telah dilakukan di HSC (Heart, Stroke, Cancer) Medical Center yang terletak di Jalan Ampang, Kuala Lumpur di mana ia bertujuan untuk mengurangkan pelepasan gas karbon ke udara yang dihasilkan oleh penggunaan dan juga sisa yang terhasil daripada aktiviti rawatan perubatan. Bagi tujuan ini, audit pengeluaran bersih (Cleaner Production, CP) telah dijalankan untuk mengenalpasti entity yang meyumbang kepada pembentukan gas karbon kepada institusi kesihatan yang telah dipilih. Kajian merangkumi aktiviti yang berkaitan dengan rawatan yang diterima oleh pesakit. Ia bermula daripada pesakit mendaftar sehingga tamatnya rawatan. CP yang dijalankan memfokus kepada pengurangan sisa, penggunaan tenaga yang efisien, dan juga penggunaan air yang optimum. Semenjak isu pemanasan global menjadi viral dan memberi kesan kepada semua ia telah menjadi satu ancaman kepada ekosistem secara keseluruhannya. Kajian ini memfokuskan kepada pengeluaran gas karbon sebelum dan selepas pelaksanaannya. Objektif kajian ini adalah untuk menghasilkan pelbagai pilihan pengeluaran bersih yang boleh digunapakai oleh premis berkenaan. Jumlah carbon foot print (CFP) akan dikira serentak dengan analisis kos. Masalah isu kesihatan yang berkaitan turut dibincangkan di dalam skop kajian ini. Kaedah pengumpulan data diperoleh melalui rekod yang terdahulu, kaedah pemerhatian dan juga maklum balas daripada individu yang berkaitan. Pilihan CP yang diperoleh dinilai untuk menguji kaedah keberkesanannya. Audit pengeluaran bersih menunjukkan 207 tan gas karbon dihasilkan sepanjang tahun hasil daripada aktiviti yang dijalankan di premis berkenaan di mana penyumbang utama adalah elektrik, diikuti dengan air dan juga sisa yang terhasil dengan peratusan sebanyak 83.5% , 15% dan 1.7%. Sebanyak sembilan alternatif telah dihasilkan di mana ia memfokus kepada pengurangan elektrik, air dan juga sisa. Kesan pelaksaan ini mampu menjimatkan hampir RM3660 sebulan. Selain itu, melalui pelaksanaan ini juga

diharap akan dapat menambahbaik dari aspek lain seperti aspek keselamatan, peningkatan produktiviti dan juga menambahbaik imej sesebuah kompani.. keputusan daripada strategi pengeluaran bersih ini juga diharap agar dapat digunapakai oleh sektor lain yang berkaitan agar ia dapat mengurangkan kadar pengeluaran gas karbon pada peringkat nasional sekaligus pada peringkat global.

ACKNOWLEDGEMENTS

I would like to thank my supervisor Prof. Ir. Dr. Abdul Aziz Bin Abdul Raman. The door to his office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it.

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LIST OF SYMBOLS AND ABBREVIATIONS

GDP	:	Gross Domestic Product
CP	:	Cleaner Production
WHO	:	World Health Organization
HSC	:	Health Screening Centre
CO_2	:	Carbon dioxide
UNEP	:	United Nations Environment Programmed
LED	:	Light Emitting Diodes

INTRODUCTION

1.1 Background

The health sector itself is making a significant contribution to climate change. Through the products and technologies, it deploys, the energy and resources it consumes, the waste it generates and the buildings it constructs and operates, the health sector is a significant source of carbon emissions around the world, and therefore an unintentional contributor to climate change trends that undermine public health. Climate change affects social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter. Extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. In the heat wave of summer 2003 in Europe for example, more than 70 000 excess deaths were recorded. High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease. These can trigger asthma, which affects around 300 million people. Ongoing temperature increases are expected to increase this burden. Measuring the health effects from climate change can only be very approximate. Nevertheless, a WHO assessment, taking into account only a subset of the possible health impacts, and assuming continued economic growth and health progress, concluded that climate change is expected to cause approximately 250 000 additional deaths per year between 2030 and 2050. Hospitals are one of the major areas that contribute to carbon foot print mostly in usage of electricity, water and waste. This is due to the fact that hospitals carry a mass number of patients that usually comes occasionally for their medical checkup. This does not include the number of patients who already warded due to various reasons. Among the activity inside hospitals is cleaning medical utensils for sterilization, clean water for dressing and surgical procedure, ongoing lighting in almost all room for multi

procedures such as dressing, scanning, changing rooms, etc. Thus, the waste accumulates is much that contributes to the total carbon foot print. The United Nations data reveals that Malaysia has contributed 187 million tonnes of CO_2 emission, which is 7.2 tonne of CO_2 emission by every Malaysian in average. Cleaner production was first introduced in Malaysia in January 1996 through projects under Danish Cooperation for Environment and Development (DANCED). There are five (5) main elements to reduce carbon footprint:

1. Waste generated reduction
2. Cost reduction
3. Usage of raw material reduction
4. Usage of natural resources reduction
5. Improve the productivity and safety

As such, cleaner production concept plays an important role in enhancing process efficiency, reducing wastage and emission to environment. Thus, beneficial gained from cleaner production does not only affect to an organization itself but also to the surrounding environment

1.2 Problem Statements

Healthcare sector, such as hospital contributed significantly to environmental problems. Carbon footprint emissions can be generated through direct and indirect emissions. Direct emissions are direct consumption for example petrol usage. While indirect emissions for example from electricity, water and waste. Therefore, there is a need to implement cleaner production strategies in the selected premise.

1. What are the main issues related with healthcare sector?
2. What are the strategies that can be implemented in greening the healthcare sector?
3. What are the impacts of the implementation?

1.3 Research aim

The study aimed to evaluate possibility of reducing carbon dioxide emission using cleaner production strategies in a selected hospital.

1.4 Research Objectives

The objectives of this study are as follows:

i. To conduct detail cleaner production audit to evaluate carbon dioxide emission generating activities in a hospital.

ii. To generate cleaner production options for critical areas identified and options to reduce waste generated in the hospital.

iii. To evaluate cleaner production options generated in term of carbon dioxide emission reduction and economic return.

1.5 Research scope

This study covers activities related with registration process of patients until discharged. Different type of examination is adhered including health check monitoring, blood and urea test, gynecology test, ultrasound of abdomen and pelvis, heart scan, x-ray of lung, bone scan, basic angiogram, eye test, ear examination and finally physician consultation. This research focuses on HSC (Heart Stroke Center) Medical Center in Jalan Ampang, Kuala Lumpur.

1.6 Report Outline

This research project consists of 5 chapters as following:

Chapter 1 introduces the background research of the project regarding the minimizing the energy and water used and reducing the wastes at medical center by introducing cleaner production option. This chapter also discuss about the problem statement, research objectives, justification, scope and limitations of research.

Chapter 2 – literature review is based on the past journal and some case studies that shows implementation of cleaner production strategy helps to reduce consumption of water, energy and generation of waste in the relevant sector thus beneficial as a large-scale impact to the environment

Chapter 3 introduces the research methodology and establishes its purpose of using cleaner production approaches and relevance for the study. Relevant research methodologies have been used such as site visit, observation, interview and data collection. Scope and limitations of the research also have been defined in this chapter. (cleaner production audit: pre-visit, interview, documents reviews, measurements, mass and energy balance, etc, CP option generation: modification/changes of process/ design,

housekeeping, reuse and recycling, etc, CP options evaluation: ROI, payback period, CO_2 emission reduction)

In Chapter 4, all the data obtained was analyzed and discussed. Results of the analysis was used to determine major issues and related CP option for implementation. Total CFP was calculated to show the effectiveness of the CP implementation. Health risk control is also discussed in this chapter. At the end of the discussion, suggestions for implementing CP at the center are mentioned

Chapter 5 conclude the finding of this study and reflected the objectives set earlier. Recommendation for future work is also added in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Global Warming

Global warming is the increase of earth's average surface temperature and its oceans due to greenhouse gases released as people burn fossil fuels. These greenhouse gases such as carbon dioxide and methane absorb heat that would otherwise bounced off the Earth's surface. Global warming has emerged has one of the most biggest environmental issue in the last two decades. Emissions like carbon dioxide, nitrous oxide and other greenhouses gases will remain in the atmosphere for many years making impossible to eliminate global warming for several decades. Since 1880, the average temperature has risen by 1.4-Fahrenheit degrees. According to the multinational Arctic Climate Impact Assessment report compiled between 2000 and 2004, the average temperature in Alaska, Western Canada and Russia have risen at twice the global average. Increasing temperatures will release more greenhouse gases, unlock methane, and cause more evaporation of water. The rate at which carbon dioxide is being dumped in to the environment is 1000 tons per second until the 2011 records. The carbon dioxide levels in the 20th century have been highest in 650,000 years. Till 1950, the levels rose by 11% and recently the levels have risen by 40%. Human activities alone release around 37 billion metric tons of carbon dioxide per year.

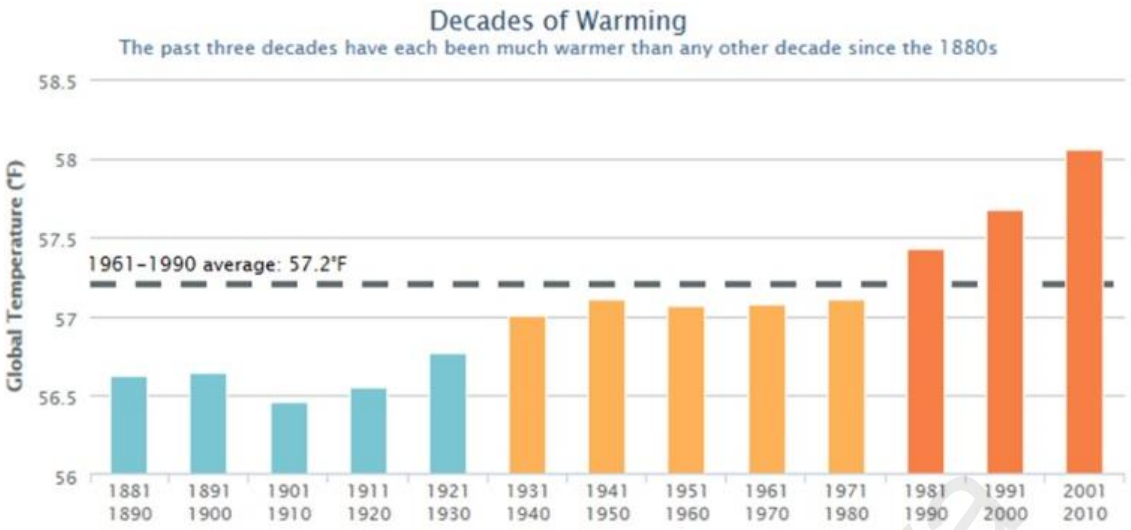


Figure 2.1: Decades Global Average Surface Temperature Increase

2.2 Effects of Global Warming to Environment

Global warming is expected to have far-reaching, long-lasting and, in many cases, devastating consequences for planet Earth. For some years, global warming, the gradual heating of Earth's surface, oceans and atmosphere, was a topic of heated debate in the scientific community. Today, the overwhelming consensus of researchers is that global warming is real and is caused by human activity, primarily the burning of fossil fuels that pump carbon dioxide (CO_2), methane and other greenhouse gases into the atmosphere.

A major report released Sept. 27, 2013, by the Intergovernmental Panel on Climate Change (IPCC) stated that scientists are more certain than ever of the link between human activities and global warming. More than 197 international scientific organizations agree that global warming is real and has been caused by human action. Below are the effects that contributed due to global warming

1. Melting glaciers, early snowmelt, and severe droughts will cause more dramatic water shortages and increase the risk of wildfires in the American West.

2. Rising sea levels will lead to coastal flooding on the Eastern Seaboard, especially in Florida, and in other areas such as the Gulf of Mexico.
3. Forests, farms, and cities will face troublesome new pests, heat waves, heavy downpours, and increased flooding. All those factors will damage or destroy agriculture and fisheries.
4. Disruption of habitats such as coral reefs and Alpine meadows could drive many plant and animal species to extinction.
5. Allergies, asthma, and infectious disease outbreaks will become more common due to increased growth of pollen-producing ragweed, higher levels of air pollution, and the spread of conditions favorable to pathogens and mosquitoes.

2.3 Carbon footprint

The total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2). Carbon footprint is the sum of all emissions of CO_2 (carbon dioxide), which were induced by activities in a given time frame. Usually a carbon footprint is calculated for the time period of a year. A carbon footprint considers all six of the Kyoto Protocol greenhouse gases: Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6).

Types of carbon foot printing:

1. Organizational

Emissions from all the activities across an organization, including buildings' energy use, industrial processes and company vehicles.

2. Value chain

Includes emissions which are outside an organization's own operations. This represents emissions from both suppliers and consumers, including all use and end of life emissions.

3. Product

Emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal

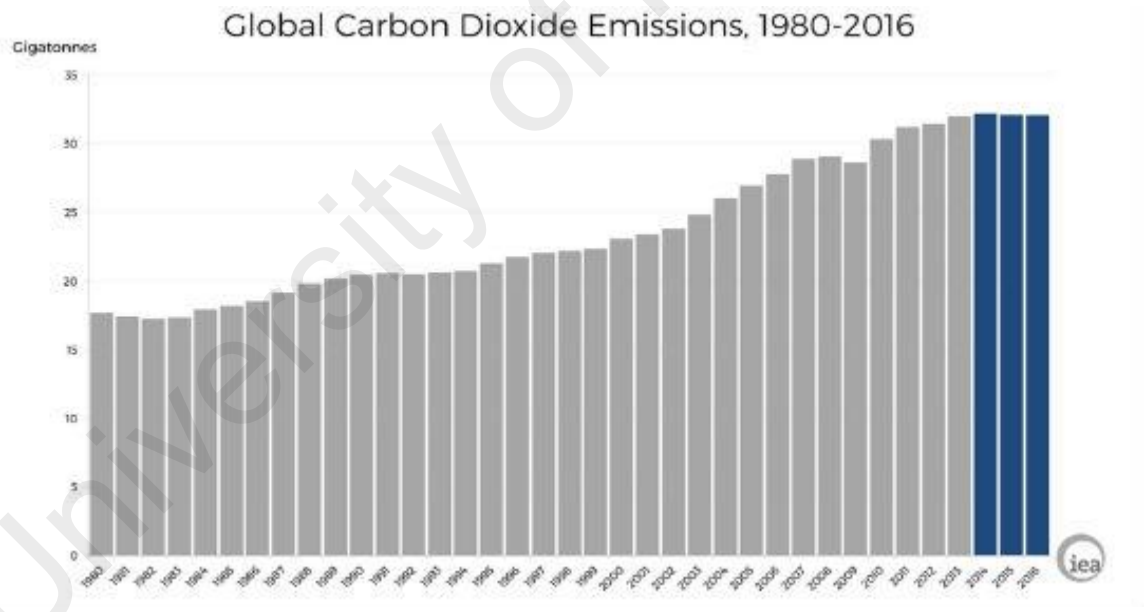


Figure 2.2: Global Carbon Dioxide Emissions (International Energy Agency,2017)

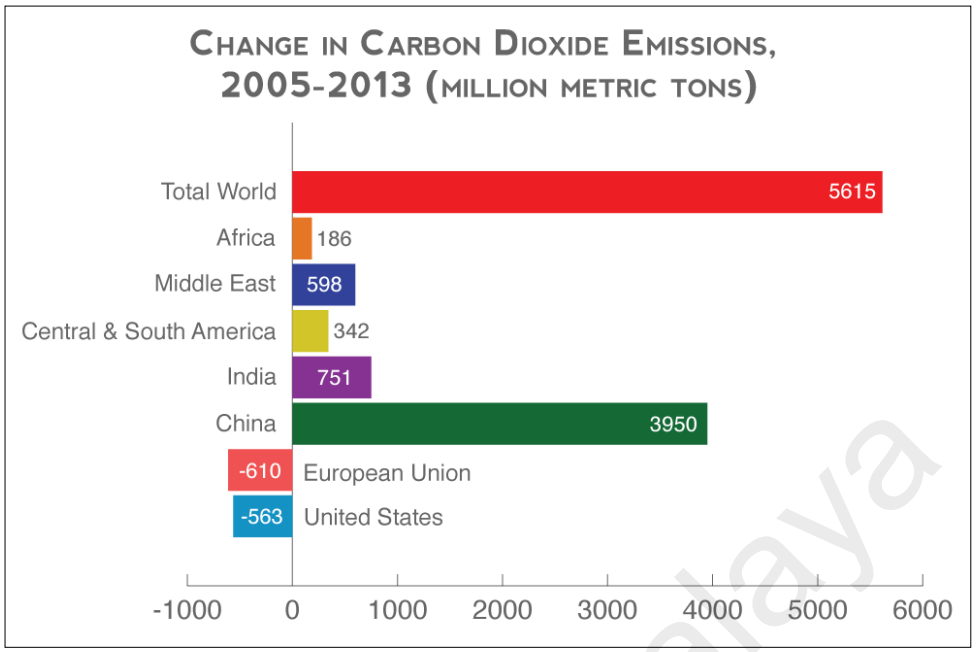


Figure 2.3: Statistical Review of world Energy (Institute for Energy Research, 2014)

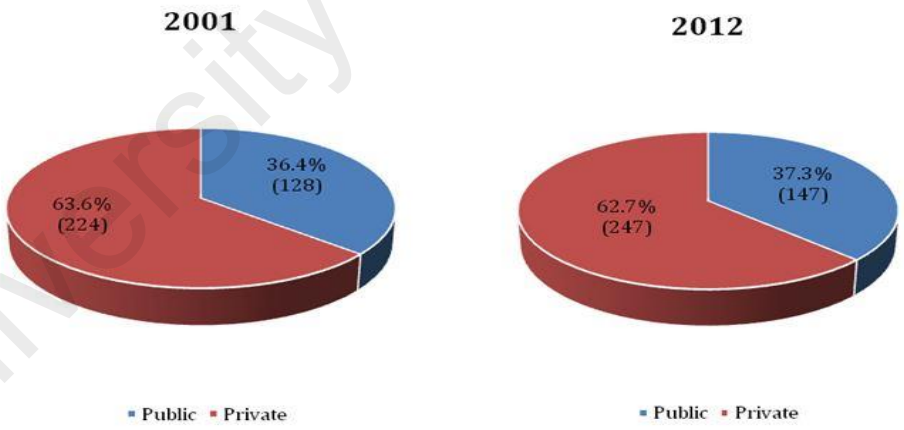
An individual or organization carbon footprint can be broken down into the primary and secondary footprints.

1. The essential impression is the whole of aggregate direct discharges of nursery gasses from the copying fossil energizes for vitality utilization and transportations. For instance, more fuel-proficient autos have a littler essential impression as do vitality – productive lights in home or office.
2. The auxiliary impression is the aggregate of backhanded discharges of nursery gasses amid the lifecycle of items utilized by an individual or association. For instance, the nursery gasses transmitted amid the generation of plastic for water bottles and in addition the vitality used to transport the water adds to the auxiliary carbon impression. Items with additionally bundling will by and large have a bigger optional impression than items with an insignificant measure of bundling.

Cleaner production is a preventive, company-specific environmental protection initiative. It is intended to minimize waste and emission with the main objective to maximize product output. (Gong, Guo, Zhang, & Cheng, 2016) Identify options to minimize waste and emissions out of industrial processes through source reduction strategies by analyzing the flow of materials and energy in a company.

2.4 Medical Centers in Malaysia

In general Malaysia can be comprised of high end hospitals that provide excellent services (Allianz, 2011). History of health services has come a long way since independence. During those time, their job is to treat the workers in the mining industry. In return, they have to pay 50 cents a year for treatment. As the mining industry expanded rapidly in the 19 centuries, Perak had the most hospitals in total of 15 including both general and district hospital (Ministry of Health, 2010)



At present, Malaysia healthcare is divided into two sectors – public and private sector. For the year 2010- 2011 there were a total of 364 hospitals that provided acute services, 135 were public hospitals and 229 private hospitals (Ministry of Health, 2011)

Figure 2.4: Number of Hospitals in Malaysia 2001 to 2012 (Ministry of Health, 2013)

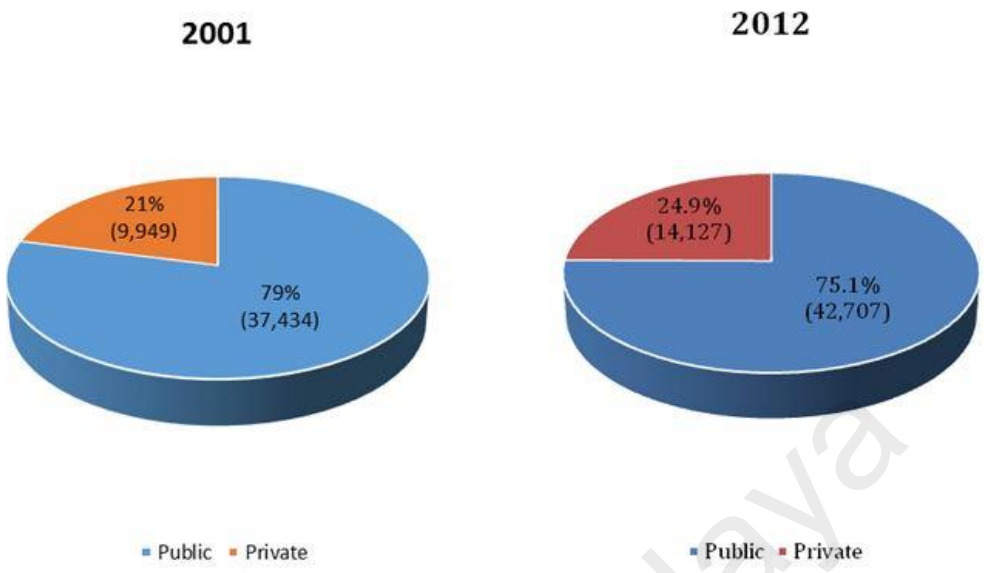


Figure 2.5: Number of Hospitals Beds in Malaysia 2001 to 2012 (Ministry of Health, 2013)

The majority of medical centers in Malaysia are concentrated in the State of Selangor and Federal territories of Wilayah Persekutuan Putrajaya, Wilayah Persekutuan Kuala Lumpur. If enumerated accordingly, both Wilayah Persekutuan Putrajaya and Wilayah Persekutuan Labuan did not have private hospitals and hence were served entirely by the public sector. (Ministry of Health, 2010)

However, hospital care in Malaysia is still heavily dominated by the public sector with Ministry of Health being the largest healthcare provider. Out of the total of 50105 beds, 37889 belongs to the public sector while the other 12216 beds were taken by the private sector (Ministry of Health, 2011)

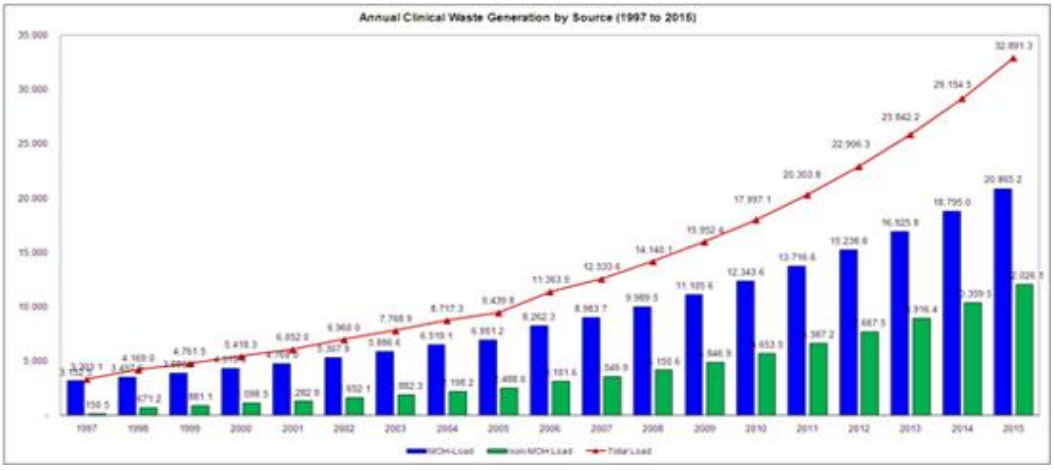


Figure 2.6: Domestic Clinical Waste in Metric Tons 1997 to 2015 (Department of Environment and Ministry of Health, Malaysia)

2.5 Activities in Hospital

Medical center is an organization for treatment, nurture the wiped out and injured, for illness study, preparing of doctors, medical caretakers and associated human services faculty. There are numerous exercises in the doctor's facilities, for example, Diagnosing and treating diseases, illness

- Diagnosing and treating ailments, disease
- Surgery for suitable patients
- Immunization for youngsters against numerous preventable maladies
- Family arranging and maternity care through particular divisions
- Emergency consideration to casualties of mischances and debacles

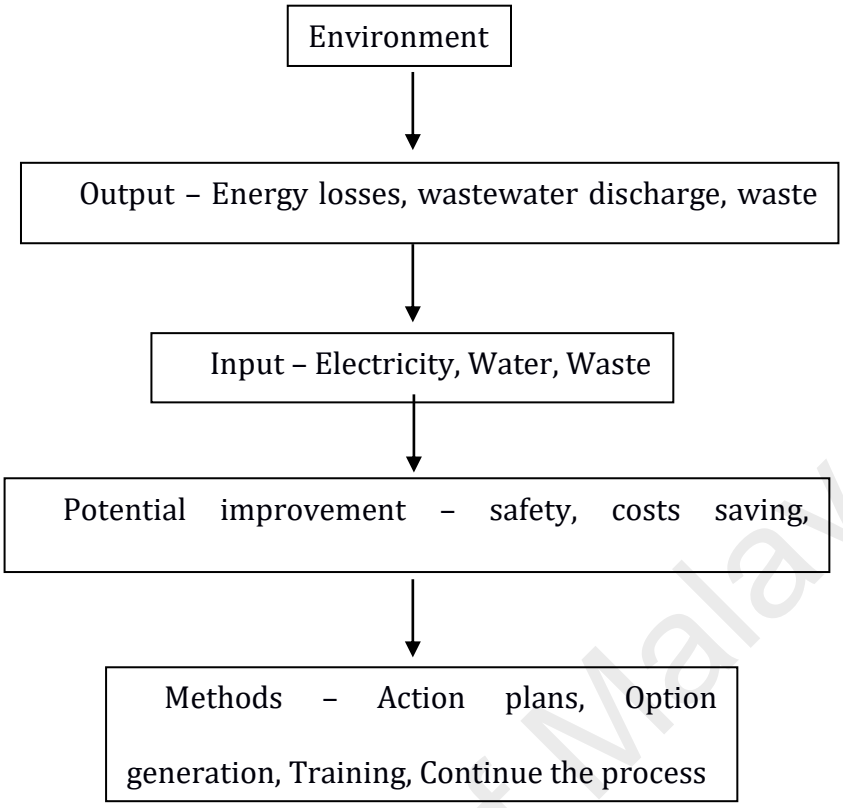


Figure 2.7: The concept of best environmental practices in hospitals

(Source: Best environmental practices in healthcare sector- Switzerland)

However, waste is generated from these activities includes a broad range of material from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials (WHO, 2011). Hospital waste includes general (domestic) and medical including infectious waste. General waste is defined as non- hazardous and do not pose an immediate threat to the man or environment (EnviroServ, 2010). While clinical waste can be defining as any waste that contains swabs, syringes, blood, human or animal tissues, drug and other cleaning devices (Zaimastura, 2005). It is including any waste from dentistry activity, research, and pharmacy.

Poor management of health care waste can potentially expose the workers and the community in particular to infection, diseases, illness, injuries and even polluting the environment. It has been reported by Velez (Velez, 2004) that 85% of the waste from hospitals can be recycled and the remaining 15% is made up of infectious and dangerous materials that need a special care when handling and disposing of. Therefore, it is essential that all medical waste material is segregated at the point of generation, appropriately treated, and disposal of safety (WHO, 2011)

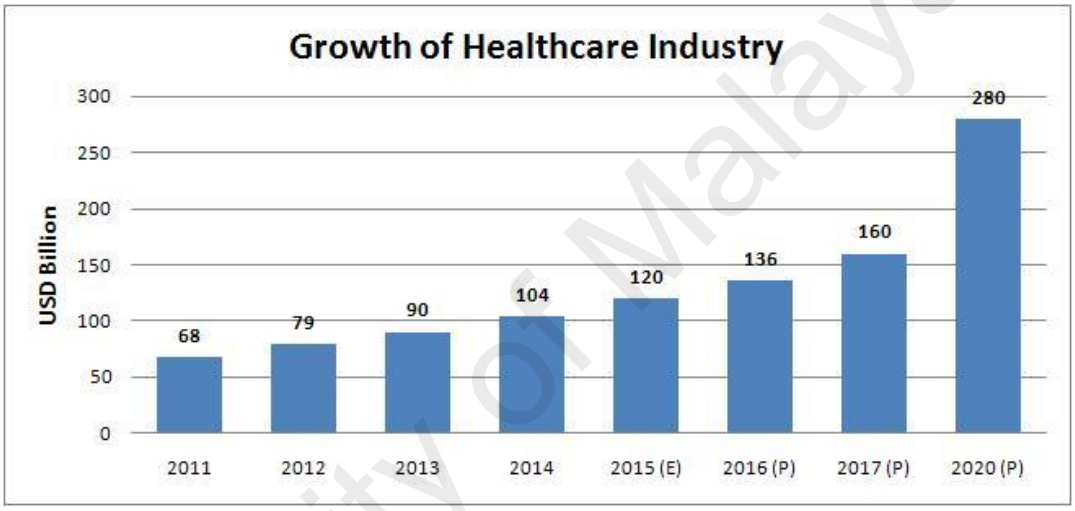


Figure 2.8: Healthcare Industry Expected Expenditure by 2020 (Medical Tourism India, 2015)

Waste generation rates within the hospitals depend on the factors (SetiawanWandsaatmaja, 1997):

I. Hospital type

The hospital can be classified into these 4 types

a) General medical and surgical hospital

b) Psychiatric hospital

c) Tuberculosis hospital

d) Other specialty hospital

II. Hospital size

Doctor's facility size is customarily dictated by the quantity of beds, which has a positive co-connection amongst size and waste era rate. This is on account of huge healing facility offers a greater number of administrations than the little ones, this most likely the case. The volume of waste produced per bed has turned out to be a powerful approach to gauge waste era in the doctor's facility class

III. Occupancy rate

One of the determinant amount of medical waste generated is occupancy rate. Ministry of Health estimated that the total amount of clinical waste generated from public hospital to be 11500 kg/day or an average 0.51 kg0occupied bed/day (Lee HengKeng, 2011)

IV. Inpatient/ outpatient ratio

When all is said in done, inpatients produce more restorative waste than do outpatients. In the USA, proportion of inpatients is 0.07 percent. However, the dependability of this proportion as a marker for waste era is impacted by the expanding number of administrations gave on an outpatient premise and an adjustment in the sort of administrations gave on the premise.

V. Geographic location

Contrasts in waste era rates may exist amongst urban and provincial healing facilities. At present, more clinics are in urban regions. Extra data on how these rates contrast is expected to decide the significance of topographical appropriation as a determinant for doctor's facility waste generation

Besides that, energy consumption is increased because of activities in the hospital. Energy use in commercial and residential buildings has steadily increased by between 20% and 40% in developed countries for the last decade (Pérez-Lombard, Ortiz, & Pout, 2008). The commercial sector counts for approximately 32% of total energy consumption in Malaysia (Saidur, 2009)

An efficient and effective heating, ventilating and air conditioning system that consumes energy is required to maintain a proper indoor environment in a hospital operational and surgical theatres (Dascalaki et al, 2008). Efficient use of energy can be considered as one of the potential and cost-effective ways of solving global energy and environmental problem (Sebitosi et al., 2008). The intelligent planning of energy supply to different categories of buildings I an important aspect to conserve energy and protect the environment.

In addition to that, water usage by the hospitals includes hygienic installations, both for patients and their visitors, laundry, the cleaning of installations and restaurants and the watering of gardens. However, one of factors that make the total consumption of water very variable is the degree of development of the country. In Denmark, for example, the consumption of cold water per bed/day is almost 600 liters, while in Austria this figure is 200 l/bed/day (Velez, 2004).

2.6 Issues Related with Medical Center

New environmental regulations and ongoing pressures on cutting costs and improving quality have forced hospitals to improve the performance of their operations, especially in developing countries. Healthcare deals with a significant amount of hazardous and non-hazardous materials and produce polluting outputs. Organizations in both industrialized and emergent countries have been urged to rationalize the way resources

are used and impact the environment (Kleindorfer et al., 2005). The healthcare sector connects to the environment in two major ways. Environmental deterioration tends to generate health problems, which need treatment and, in consequence, healthcare services. Simultaneously, the waste generated by the sector, pollution and use of natural resources to provide these services should be minimized to achieve sustainability. As per Zimmer and McKinley (2008), hospitals in the United States produce approximately 6,700 tons of waste per day and healthcare waste is the fourth largest contributor of mercury to the environment. As the development of environmental awareness and regulations progressed, demands to cut costs related to public expenditure in healthcare have forced hospitals and other entities to improve their environmental performance (Karlsson and Ohman, 2005). The value represented by patients' health outcomes by currency unit invested has been connected to improvements in quality and performance (Porter, 2010). These improvements have led to the reduction of the waste of resources and an enhanced perception of medical care effectiveness and patient satisfaction (Maki et al., 2008). There are also safety issues related surrounding hospital environment for both patients and staff (Bert Sadlier, 2006)

- Hazards for staff – biological hazards occur through personal contact between the patient and the staff member. Physical hazards may occur from injury, radiation exposure and violence. Chemical hazards include the use of cleaning supplies, handling of drugs, leakage of anesthetic gases in the premise.
- Patient hazards – includes infections transmitted in the hospital. Injuries happens when proper treatment and supervision is lacking.

- Safety concerns – this includes injury, illness, disease exposure, disaster management, evacuation implementation, food preparation and contaminated waste.

2.7 Cleaner Production Concept

The terms cleaner production was initially beginning in September 1990, by the United Nations Environmental Program, the formal UNEP meaning of 'Cleaner Production" is as the persistent use of an incorporated preventive ecological system connected to procedures, items and administrations to build effectiveness and lessen dangers for human and environment (UNEP, 1994)

Cleaner production activities include measures such as pollution prevention, source reduction, waste minimization and eco efficiency. This can be achieved in various ways. A division in 5 prevention practices is most common (UNEP, 2002).

- Good housekeeping
- Changes in raw material
- Technology modification
- Product modification
- On site recycling

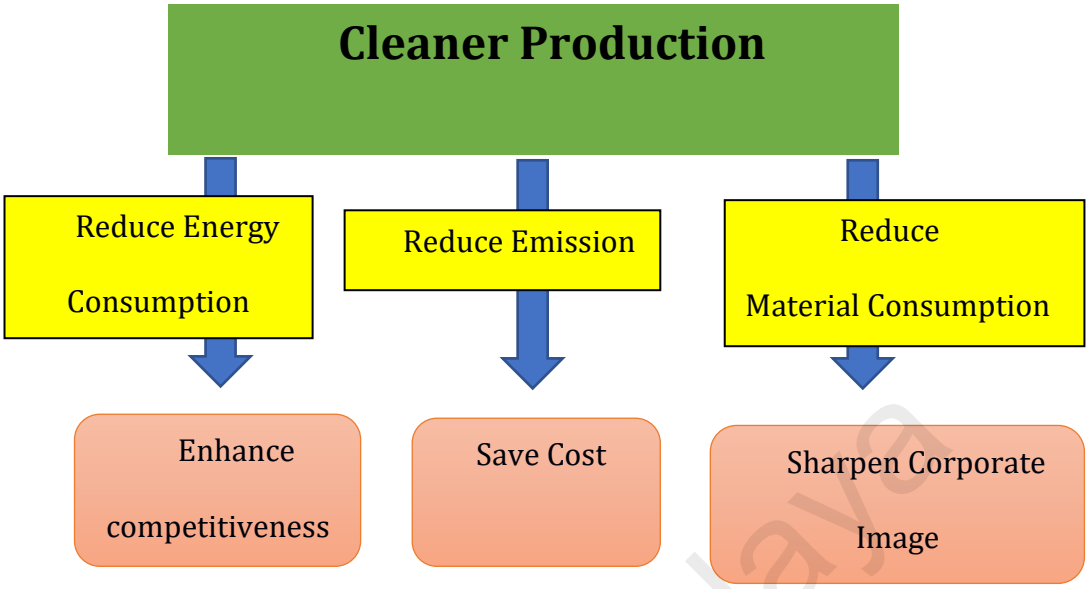


Figure 2.9: Cleaner Production (CP Partnership,2010)

Cleaner production can be executed in all enterprises, whether they are enormous or little association. For most organizations, there is a capability of decreasing the asset consumption with 10% - 15% without any big investment. The advantage of cleaner production is improved production efficiency, more effective usage of raw material, water and energy, recovery of profitable items, less contamination, lower expenses of waste transfer and wastewater treatment, better company image and improved occupational health and safety (Department of Industrial Techniques Cambodian Cleaner Production Programme,2006)

Application of the cleaner production are for the processes, products and services. For the processors, cleaner production includes conserving raw material and energy, eliminating the use of toxic raw materials and reducing the quantity and toxicity of all emissions. Besides that, for product involves reducing the negative effects of the product throughout its life cycle, from the extraction of the raw materials right through to the product's ultimate disposal. For services, the strategy focuses on incorporating the environmental concerns into designing and delivering services (DOE, 2002)

2.8 Cleaner Production Audit

Cleaner production audit is the first step towards managing, controlling and improving the environmental performance for a company. If company was not concerned about environmental impacts of its production, the best way to establish the actual status and determine the best approach to reduce waste, wastewater and emissions are the audit. (UNIDO 2011)

Cleaner production methodology has 6 steps to complete the project. Each step is briefly discussed below ("Methodology: Cleaner Production Virtual Centre Malaysia", 2010)

Step 1: Getting Started

Organization to planning of cleaner production audit including the designation of cleaner production team, listing major process steps to select the audit focus.

Step 2: Analysis Process Steps

Preparation of detailed process flow diagrams for the selected audit focus no preparation of material/ energy balance to quantify waste, its costs and causes thereof.

Step 3: Generating Cleaner Production Opportunities

Identification of potential cleaner production opportunities and preliminary selection of workable cleaner production opportunities.

Step 4: Feasibility Analysis

Evaluation of the technical and financial feasibility and environmental desirability of cleaner production option in order to select technological and economical feasible cleaner production solutions.

Step 5: Implementing and Monitoring Cleaner Production Solutions

Preparation for actual implementation of feasible cleaner production solutions, and monitoring of the results achieved by their implementations.

Step 6: Sustainable Cleaner Production

Human resource development and strategies for sustaining of cleaner production and selection of another cleaner production audit focus.

2.9 Cleaner Production Options

Cleaner production options are the changes concern not only the equipment, but also the operation and management of the company. Cleaner production options can be group into (Department of Industrial Techniques Cambodian Cleaner Production Programmed, 2006)

Waste diminishment at source while heading off to the wellspring of contamination is key thought of cleaner generation

a) Good housekeeping – it requires no ventures and can be actualized when the choices are distinguished.

b) Better process control – to guarantee that the procedure condition is ideal with the admiration to the asset utilization, creation and waste era

c) Material substitution – to buy higher quality material that gives a higher proficiency. Regularly there is an immediate connection between the nature of the crude materials and the sum and the nature of the items

d) Equipment adjustment – to enhance the current hardware so less material is squandered

e) New process innovation – to introduce present day and more proficient hardware

i. Recycling when waste streams that are unavoidable might be recycled within the company or might be sold as by products

   a) Onsite recovery and reuse – to collect waste and reuse it in the same or different part of the production. One simple example is to reuse rinse water from one process to another cleaning process

   b) Creation by product – to collect and treat 'waste streams' so they can be sold to consumers or to other companies.

ii. Product modification where improving the products so they pollute less is also a fundamental idea of cleaner production

   a) Changing the product – to rethink the product no the requirement to the product

   b) Changing packaging – to minimize the packaging and maintaining the protection of the product

Cleaner production can produce through the type of agendas for the three key types of squanders (materials, vitality and water) and are introduced for each of the key regions of healing center movement (e.g. obtaining). The agenda ought to empower to rapidly distinguish alternatives that can be suitable to the healing center. The cleaner creation alternative has been assembled from different sources.

2.10 Case Studies

2.10.1 CP Case Study 1: Public Health Risks from Mismanagement Healthcare Waste, Shinyanga Municipality Health Facilities

The case study focused on healthcare wastes, which are of great importance due to their potential environmental hazards and public health risks. Pollutants from healthcare units include biohazardous waste, chemicals, pharmaceutical wastes, pathological wastes, radioactive substances, and genotoxic wastes, which can cause a variety of adverse effects on human beings and the environment. As a result, World Health Organization (WHO) has considered healthcare wastes as special wastes and it is now commonly acknowledged that certain categories of healthcare wastes are among the most hazardous and potentially dangerous of all wastes arising in communities. The hospitals are comprised of departments, like wards, the casualty, the minor operating theatre, the major operating theatre, maternity section, laboratory, and X-ray section among others. The primary data were collected using questionnaire, interviews, and observation checklists and secondary data were obtained from the hospital documents. It is found that that training was not provided to the waste management staff, doctors, and other personnel on management of healthcare wastes and their potential hazards. In accordance with administrators, the major reasons for lack of training were budget constraints (67%), lack of skilled trainers (23%), and lack of willingness to provide training (10%).An overwhelming majority of the health employees who participated in the study (81%) are not using personal protective equipment (PPE), which include gum boots, gloves, caps, and overall coats when handling healthcare wastes. Provision education and training to healthcare workers were considered an important requirement. By building a strong knowledge base among healthcare workers, they will engage in

practices that protect them and their patients as well as the general public and the environment.

2.10.2 CP Case Study 2: Cleaner Production in Jordan Hospitals

Hospitals operate 24 hours a day, 365 days a year and have various pieces of equipment for producing food, consume fuel for generating energy and also demand a variety of other common resources in considerable quantities, including rubber, plastics and paper products. In view of this context, it has been shown that hospitals carry out functions similar to those found in industry, such as laundry, transport, cleaning, food, photographic processing, and others. Hospitals generate a great quantity of waste and demand a great quantity of resources such as energy and water. The generation of waste by the sector is significant and constant throughout the year (Davies and Lowe, 1999)

It has been reported by Velez (2004) that 85% of the waste from the hospitals can be recycled and remaining 15% is made up of infectious and dangerous materials that need a special care when handling and disposing of it. Therefore, on site reuse and recycling is one of the efficient method to be implemented. Other point that has been emphasized is through good operating practices. Good housekeeping changes are related to procedural, administrative, or institutional measures that can be employed by a company to minimize wastes and emissions and to reduce water and energy consumptions in addition to conserve health and environment. It is thought that such measures are efficiency improvements and good management practices, which are able to be implemented in most areas of a company at a relatively low cost. As an example, a good operating practice is improving handling and inventory practices to reduce the loss of input materials (UNEP, 2002).

2.10.3 CP Case Study 3: Cleaning in Healthcare Facilities

Cleaning of healthcare facilities is performed for medical and cultural reasons. Maintaining an environment with a low pathogenic burden is essential for avoiding complications during the care and recuperation of patients. A healthy, safe, and aesthetically pleasing space with clean surfaces is comforting to patients and their families by giving an impression of good quality care without additional health hazards. The importance of infection prevention and control is increasing due to rapidly developing strains of multi-drug resistant organisms (MDROs) that can result in serious illness and even death in workers and patients. In 2002, US hospitals reported about 1.7 million HAIs (Healthcare Associate Infections), associated with almost 99,000 deaths. Steps taken to practice green health approach:

• **Step 1**: Form a team and gain commitment;

• **Step 2**: Review current products and practices (conduct inventories of cleaning products, equipment, policies, and operations);

• **Step 3**: Evaluate and categorize facility areas (identify high risk, medium risk, and low risk care areas, patient rooms);

• **Step 4**: Determine evaluation criteria for products and operations (review product attributes, GPO contracts, certified products, and changes in operations);

• **Step 5**: Select products (e.g., general, toilet bowl, carpet, and glass cleaners have been certified under Green Seal GS-37 and GS-40 products; floor strippers and waxes; and types by usage of disinfectants);

• **Step 6**: Develop a pilot plan (pilot area(s), pilot evaluation criteria, feedback solicitation, changes in work processes, pre-implementation and post-implementation surveys for facility staff, patients and visitors);

• **Step 7**: Execute the pilot (incl. training and feedback);

• **Step 8**: Evaluate the pilot (post-pilot surveys for staff, patients, visitors)

• **Step 9**: Celebrate success (develop press releases, case studies, and materials for future green cleaning projects); and

• **Step 10**: Expand the efforts by institutionalizing the program (e.g., facility's cleaning chemical purchasing standards excluding products containing toxic chemicals in favor of safer products successfully used).

.2.10.4 CP Case Study 4: Bronson Methodist Hospital

Before the implementation of CP, the study shows a significant amount of water and electricity usage. A few options have been taken to overcome the problems such as place timer/ occupancy sensors to control the lighting in the corridors, install water saving equipment for taps and showers and use dual flushing system in public and patient's toilets. Others is to install solar heating system to provide hot water.

2.11 Cleaner Production Benefits

Based on previous study, cleaner production can bring benefits from many aspects. Some cleaner production method might involve advanced technology installed and certain budget with it, but ultimately it will lead to a better result in total.

1. Financial benefit

Some cleaner production requires a bit of investment. If financial is involved, the paid back period is crucial for the company to regain its profit back. It may require a huge amount in the beginning but in the long terms it may be able to generate huge saving. Some method can even get paid within a short period of time. In short, return of investment is the key factor. On the other hand, it is proven that by implementing cleaner production strategies it can helps to reduce the cost of operation through process improvement. It also can be beneficial to the environment as well. Moreover, company that initially implementing this method are more susceptible to get approval for their bank loan (Staniskis,2003)

2. Environmental benefit

Cleaner production can neither helps to reduce the consumption of raw material and reduce the amount of waste. Impact to the environment is that it can reduce global warming effects. Therefore, it is critical in order to save the environment greener technologies being introduced to the market near future.

3. Productivity of Staff

It can help to enhance the company image. When this attribute enhances, the productivity of the staff will also be rising and the morale will also be uplifted. Advantage on this is other aspects such as legal compliance, working environment and service quality can also be improved (Siaminwe,2005). Company annual key index performance can be set based on the results achieved through cleaner production implementation. Indirectly, morale of the staff can be cultivated to become more efficient and motivated to work.

4. Corporate reputation and image

When image of the company is publicly advertised for their triumph through implementing cleaner production, this can help to enhance the transparency and confidence among shareholders, clients, and public. Besides that, cleaner production would also create positive image of the company and therefore can attract more potential investors and customers.

5. Energy efficiency and waste management

Cleaner production can help to reduce electricity and water consumption in overall workflow. Waste also can be deducted to a lower margin. This can help to improve the workplace environment and all staff can work comfortably

6. Housekeeping

A good housekeeping helps to reduce product damage, company's loss and occurrence of unfavorable incident. It is proved that cleaner production options are based on good housekeeping (Christ & Burritt, 2013). Good housekeeping helps to minimize any danger and maintain cleanliness of the facility. Results shows that company's loss are mainly due to poor planning and frequent change of production model (Akkerman & Van Donk, 2008). Loss can be prevented by having a proper management in the company.

7. Improve product/service quality

Studies show that in order to improve the environmental performance, it is not necessary to change the existing equipment or system but it can be done on site recycling with minimum investment cost (Dahodwalla,2000)

2.12 Cleaner Production Challenges

Here were numerous difficulties to guarantee that the cleaner creation meets the desires of the individuals who advance an economical type of improvement. Some of the challenges faced were myths about cleaner production, mind hindrances against cleaner production, and demonstrated and viable thought. There are numerous false impressions about cleaner creation, for example,

- Cleaner creation is profited for vast organizations
- Leaner creation requires huge speculations
- Cleaner generation requires present day innovation
- It has restricted potential and won't keep going long

Apart of the mental block such as:

- Fear of being seen as a fool
- Fear of aggravating convention
- Fear of being distant from everyone else
- Fear of being reprimanded
- Fear of being abused
- Fear of committing errors

Then for proven no effective idea is not following the idea:

- Let’s consider it later
- We have effectively attempted it

- It is not the correct time
- You don't comprehend the entire issue

2.13 Environmental Impact to Healthcare

Health care services are also energy-intensive. Hospitals are the second-most energy-intensive commercial buildings in the country, after food service facilities. Hospitals are typically large buildings, open 24 hours a day, seven days a week, and contain several energy-intensive activities, including sophisticated heating, cooling, and ventilation systems, computing, medical and laboratory equipment use, sterilization, refrigeration, laundry, as well as food service. In addition to energy used on site in the form of heating fuels and electricity, the health care system also uses vast quantities of energy-intensive goods and services, such as pharmaceuticals and medical devices, which require significant energy inputs for their manufacturing. (EIA,2012)

In 2009, Chung and Meltzer says health care plays in the physical economy of the country. They report that health care contributes 8% of the nation's greenhouse gas (GHG) emissions both from health care activities and direct purchases (46%) and from indirect activities associated with the supply chain of health care-related goods and services (54%).

Efforts are underway to quantify the climate impacts of specific medical devices or supplies and procedures, with the overall objective of finding equally effective but less carbon-intensive ways to deliver care (Eckelman M,2015)

Patients, visitors and workers who handle or come into proximity to waste are potential occupational exposures with direct exposure. However, all individuals are exposed to hazardous healthcare wastes are potentially at risk, including those within healthcare

establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management (WHO, 2003). The main group at risk are the following

- Medical doctors, nurses, healthcare auxiliaries and hospital maintenance personnel
- Patients
- Visitors
- Workers in support services
- Workers in waste disposal facilities

Occupational risks are also serious concern outside of the institution. Landfill and refuse incinerator operators try to segregate waste for recycling and another disposal route. Municipal waste facilities also are more likely to carefully screen wastes from businesses and institutions to prevent entry of those wastes that are perceived to be hazardous to their worker or the environment (SetiawanWandsaatmaja, 1997)

Environmental risks include the possibility of a release of waste to ground water, surface water or air (SetiawanWandsaatmaja, 1997). Environmental pacts associated with hospital functions and operations. The environmental consequences which result from the pollution of air include the enhanced greenhouse effect (global warming), ozone layer depletion, acid rain, phytotoxic, damage to material and aesthetics (door and visibility) and the human health threat associated with toxin emission (Victoria-EPA, 2010). The environment consequences also associated with discharges to storm water r sewer include contamination of water supply, pollution of water ways used for recreational purposes, algal blooms, degradation of aquatic ecosystems and diminished

aesthetic enjoyment. The natural resource depletion issues relate primarily to forest, fossil fuel resources, wasteful water use and landfill waste disposal.

I. Greenhouse gas

II. Ozone depletion

III. Air emission

IV. Storm water discharges

Discharge of the storm water drainage systems are a significant threat to human health and natural environment. Pollutants which enter the storm water system proceed untreated into these natural waterways. Particulate matter which enters waterways increases the turbidity of the water and can potentially hinder the passage of the sunlight necessarily for the photosynthetic of aquatic plants.

V. Resource depletion

Resource depletion refers to the consumption of natural resources at rate greater than that at which they are replenished. The disposal of consumable items contributes to resource depletion.

VI. Water use

Water is important to many hospital functions. It is necessary for the delivery of patient care, production of steam, laundry, garden etc. There are number of environmental impacts associated with the supply use and disposal of water. Water supply facilities require large engineering works which have significant environmental consequences. Energy is required to construct and operate water distribution systems.

Moreover, additional pressure is place on the sewage system by increased water consumption potentially decreasing the effectiveness of treatment processes.

In addition to direct emissions from health care facilities, there are also indirect emissions that occur as a consequence of producing the electricity and materials that those facilities use. In this way, the health care sector is interconnected with and supported by industrial activities that emit much of the pollution to air, water, and soils nationally, including particulate matter, sulfur and nitrogen oxides, persistent organic pollutants, and toxic metals. These very emissions contribute to the national disease burden. Fine particulate matter is the leading cause of air pollution-related disease, with 87% of the world's population living in areas exceeding the World Health Organization (WHO) Air Quality Guideline of 10 μg/m3 PM2.5 (Brauer M, 2013)

2.14 Summary of Literature Review

Based on the relevant literature review, it can be concluded that it is important to conduct CP audit in the healthcare field. Significant amount of CO_2 emission is generated from the healthcare center and apparently contributes to greenhouse effects. However, there are challenges that overhold the CP implementation such as financial support and also management commitment and awareness. Some CP might require advanced technology but there are always alternatives such as by reviewing the current procedures for optimum result. CP option can help to reduce CO_2 emission and also enhance efficiency and productivity as well as creating a safe working environment for the workers.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, there were various steps that have been adopted to fulfill the objectives of this cleaner production implementation. This chapter includes discussion on method of data collection, approach used, methods available and data analysis.

3.2 Overall Research Activities

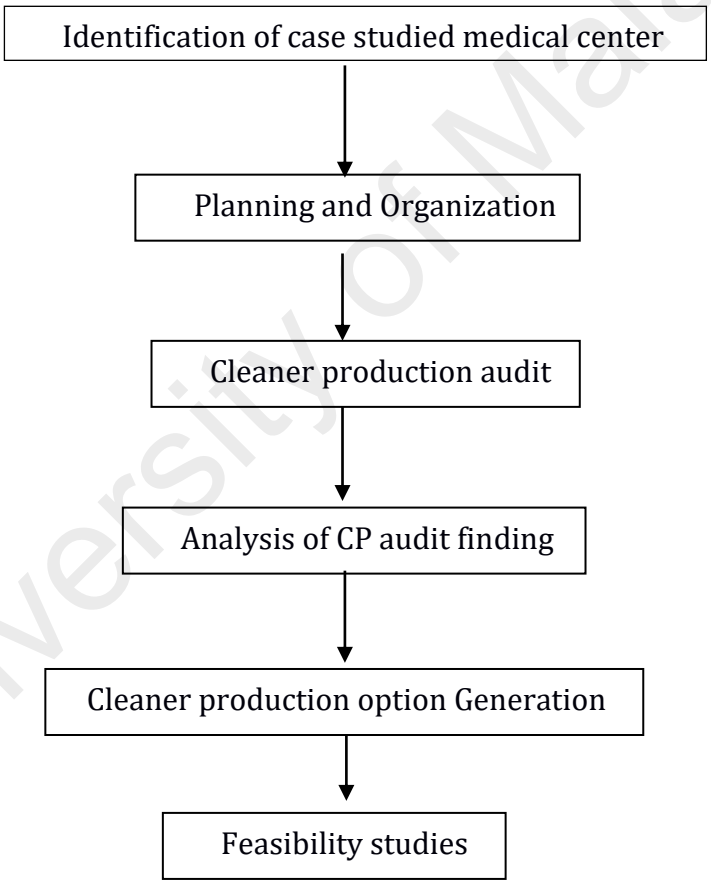


Figure 3.1 Overall Research Methodology

3.3 Company Details

This study has been carried out in a medical center with a total number of 91 workers. The premise located in Jalan Ampang, Kuala Lumpur. It operates 24 hours, 6 days a week. Mainly the package that were offered to the patients are the screening packages that mainly targets about the heart function. There are several tests being done here inclusive of blood test, vital sign test, cardiac scan, ultrasound, hearing and eye test. Normally average per patient will take around 2-2.5 hours to complete the test. Patient needs to be fasted on the day of examination. An average of 20 patients are treated daily. There are also 6 bed wards located on the upper floor to assist patients that needs a thorough check up especially an elderly that requires them to spend an overnight at the medical center. Permission have been obtained by the management with a proper official letter to conduct the study. Premise is certified with ISO 900.

3.4 Planning and organization

Approval was gained through meeting with the CEO of the medical center to have access on the data collected and to run the overall research at the center selected. During the meeting with the board of directors, issues discussed were topic on audit objectives, types of information needed, and audit plan in terms of parameters and time frame for overall planning. Company approval letter is attached in Appendix A.

3.5 Cleaner Production Audit

Detailed cleaner production audit was conducted to quantify resource consumption find suitable cleaner production option to be implemented. Following topics was covered during conducting a CP audit:

- Electricity consumption
- Water consumption
- Waste consumption

As for the electricity consumption, observation shows that ongoing usage are contributed by air conditioner, machines, computers and lighting. Total kWh consumption will be collected through monthly TNB bill received for further calculation. Same goes with water consumption, monthly bill will be examined for further assessment. Domestic water and process water both will be measure to quantify for this measurement. Observation also shows that there is enough container in keeping up with clinical and general waste. All unwanted waste is allocated at a specific area for disposal by the contractor. Upon interviewing session with the workers at the area, it is discovered that they are fully aware and know how to take care of their own health. Information collected from this audit will be use as a point reference in generating the cleaner production option. Questionnaire checklist is attached in Appendix B.

3.6 Analysis of Audit Finding and Quantification of CO_2 Emission

The CO_2 emission was quantified using the factor based approach according to Intergovernmental Panel on Climate Change (IPCC) method which has been developed to estimate GHG emission for major economic sectors. (Rahim & Raman, 2015)

There three entities involved in overall process which is electrical, waste water and waste accumulated for both general and clinical waste. Data collected were analyzed to identify issues that exist in the premise due to high consumption of resources and waste generation hence this was done by quantifying carbon emission generated from daily workflow.

Quantification of carbon emission were done according to formula developed by Intergovernmental Panel of Climate Change (IPCC). Equation 1 shows the formula while list of emission factors is included in Table 3.1.

$$CO_2 \text{ emission (kg } CO_2) = \Sigma \text{ (Consumption or generation }_{entity} \text{ x Emission Factor }_{Entity}) \quad \text{Eqn (3.1)}$$

Table 3.1: Emission Factor

Resources and waste	Emission factor	Unit	Reference
Electricity	0.67	kg CO_2/kWh	(Rahim & Raman,2017)
Waste water	1	kg CO_2/m^3	(Rahim & Raman,2017)
Solid Waste	3.7	kg CO_2/kg	(IPCC, 2006)
Clinical Waste	0.57	kg CO_2/kg	(DEFRA,2010)

3.7 Cleaner Production Option Generation

Cleaner production options were generated based on issues identified focusing on reducing water and energy consumption through modification of operating parameters and substitution of material. Furthermore, cleaner production options were also generated for managing waste more efficiently through 3R, and waste type segregation practices.

3.8 Feasibility Studies

Cleaner production generated were evaluated in terms of environmental and economic return.

3.9 Cost Analysis

Cost analysis is performed to know the relevant cost involved during the workflow process. By doing so, options for the best cost saving can be rule out to determined its effectiveness and its usefulness to lessen the overall uptake.

3.10 Return of Investment

Return of investment (ROI) also known as paid back period, is the estimated period to get the return from the investment. It is an important element to propose to the idea or cleaner production options to management. The shorter period of return will generate greater results to the company. Investment without return will increase the barrier for approval. ROI is calculated based on estimated equation below: (DOE, 2010)

ROI = T1 / TS

Where:

ROI = Return of Investment

TI = Total Investment

TS = Total Saving

3.11 Safety Precaution

Safety precaution was taken thoroughly during the audit activities at the premise. Personal protective equipment (PPE) usage was compulsory and standard operating procedure was followed during walkthrough visit. Person in charge will ensure that all staff are obliged to this order. Best practice requires workers to wear gloves, and protective clothing to help prevent exposure to bacteria, dust, blood or any spillage or sample taken from the patients. Besides PPE, it is important to read instructions manuals fully, so everyone can fully understand on how to handle, activate and operate any equipment. Throughout the study, person in charge (PIC) was encouraged to monitor and to ensure all safety measures were being practiced to prevent any incidents from happens. Audit was done during non-peak hour to avoid disturbance of workflow.

CHAPTER 4

RESULTS AND DISCUSSSION

In this chapter, the main focus is at energy and water consumption and waste management in the selected medical center. It will also discuss about the safety for the health workers. Result before and after the implementation of cleaner production will also be discussed. Cleaner production audit will rectify what are the problem from this study and what are the process need to be change or to be improve.

4.1 Cleaner Production Audit Findings

Data collected was tabulated in Table 4.1.

Table 4.1: Resources Consumption and Waste Generation

No	Entities	Amount/ month
1	Water	45 m^3
2	Electrical	258 kWh
3	Waste	951 kg

4.2 Electricity Consumption

Estimation of electricity consumption can be obtained for the equipment by the consumption based on kWh of usage per day.

Table 4.2 Electricity Consumption

Type of Usage	Unit	KiloWatt (kW)	Total Usage / day	Consumption/month (kWh/month)
Air Conditioners	21	1.1	24 Hours	14,414
Lighting	45	0.1	10 Hours	1170
Computer Desktop	33	0.3	10 Hours	2574

According to Table 4.2, the highest amount of electricity consumption at this ward level 5 was air conditioner (Daikin 1.5 HP) about 564 kWh/Units/Day. It is because air conditioner operated about 24 hours per day except during maintenance. Air conditioner in this ward level 5 is split type which connects one indoor unit to an outdoor unit. However, there was no facility to shut off operation to spaces not in use. Temperature in this ward level 5 also set between 16^0C – 23^{o}C. There were followed by computer desktop about 82.5 kWh/Units/Day. Computer desktop also turns on 10 hours per day. Computer desktop type is using HP Pavillion A6600F brand. Electricity consumption for lighting (PhilipsLifemax) was 16.2 kWh/Units/Day. This lighting operated about 10 hours per day and this type is mostly recessed fluorescent tube. Lighting is mostly using the LED type. Therefore, the consumption is quite low. Transparent roof can be opted to reduce the usage of fluorescent tube during the day. According to the Malaysian Standard, MS ISO 8995:2005, general walkway in corridor with 100 lux is sufficient enough to cover the area. However, standard of AS/NZS 1680.2.2 interior and workplace lighting recommends illumination (lux) for corridors and walkways around 40 lux only which is lower than the Malaysian standard. Nevertheless, we can still

follow under Malaysian Standard. Percentage reduction for overall energy consumption is 30.1%.

4.3 Water Consumption

From the observation, frequent cleaning is done for hygiene purpose. Furthermore, water is used without proper monitoring. Thus, water continuously flow while it is not use under these possible situation:

1. The operator has just turned on the valve and not ready for cleaning
2. The valve is opened while the operator is performing some other tasks

These two actions can deliberately cause water waste. This can be preventing by changing the method through implementation of water valve.

Table 4.3: Water Consumption

Types of usage	Amount m^3/ month
Cleaning	57
Domestic (toilet, etc.)	15
Total	72

4.4 Waste Generation

Mostly generated waste in the hospital are typical clinical waste and general waste. Clinical waste generated from the numerous procedure during the treatment plan. General waste came from other sources, such as food waste from patients and visitors who came in.

4.4.1 Domestic Waste

General waste is anything but a non-hazardous type of waste. Normally it comes from the patients or visitors to the center.

Table 4.4 General Waste Generation before CP Options

Type of waste	Description	Source of waste	Amount/ month
Food packaging	Polystyrene pack, paper pack, paper cup	Waiting area	313 kg/month
Food waste	Fruits, rice, biscuits	Waiting area	
Plastic	Drink bottle and food container	Waiting area	
Paper	Newspaper, magazines, tissue	Waiting area	
Aluminum cans	Soft drink can	Waiting area	

4.4.2 Clinical Waste

Basic clinical use is syringe, cotton, gauze and IV sets. Waste identification is essential due to its hazardous and infectious nature will continue to threaten people. By identifying the waste, the health workers can work safely without need to worry of the infection and hazardous effect. Clinical waste is divided into 4 groups.

Table 4.5 Clinical Waste Category

Group	Source of waste/ activity	Amount/month
A	• Soiled surgical dressing, cotton wool, gloves, swabs, plaster and bandaging which have come into contact with blood or wounds, cloth and wiping material used to clean up body fluids, and spills of blood • Material other than linen from cases of infectious disease (eg. Blood, urine, stool) • All human tissue and all related swabs and dressings	120kg/month
B	Syringes, needles, cartridges	
C	Expired drugs, including drugs that have been spilled or contaminated or to be discarded because they are no longer required	
D	Used disposable bed-pan linen, urine containers	

Standard method is to use plastic bag and plastic container for clinical waste. Each of the plastics needs to have biohazard symbol and this action is already stated under Environment Quality Act (Scheduled Waste) 1989 in Third Schedule, (Regulation 8)

<u>As per indicated</u>

Black bags – General Waste

Yellow bags – Clinical Waste

4.4.3 Waste Water Generated

It was quantified that 72m^3 of waste water was generated monthly from domestic usage in the premise mainly from toilet usage and cleaning purposes. Subsequently, the quantification was done according to SPAN guideline.

Table 4.6: Detailed Waste Water Generated

Types of usage	Amount m^3/ month
Cleaning	57
Domestic (toilet, etc.)	15
Total	72

4.5 Other Aspects

Other aspects include productivity issues. For example, due to low temperature of air-conditioner has cause discomfort to working staff because most of the time they have to wear sweater to combat coldness. This is because on average staff assigned to each department is between 3to 6 person per room.

4.6 Quantification of Total Carbon Emission Generation

Calculation was done according to formula shown in Equation 3.1 with the use of Equation Factor listed in Table 3.1 and electricity was found to be the highest peak.

Table 4.7: Quantification of Carbon Emission Generation

No	Entity	Amount/month	Carbon emission/month (ton CO_2)	Percentage (%)
1	Water (m^3)	4.5	3.0	13
2	Electricity (kWh)	258.0	17	73
3	Waste (kg)	951	3.5	1
4	Waste water	4.5	3.0	13
	TOTAL		23.5	100

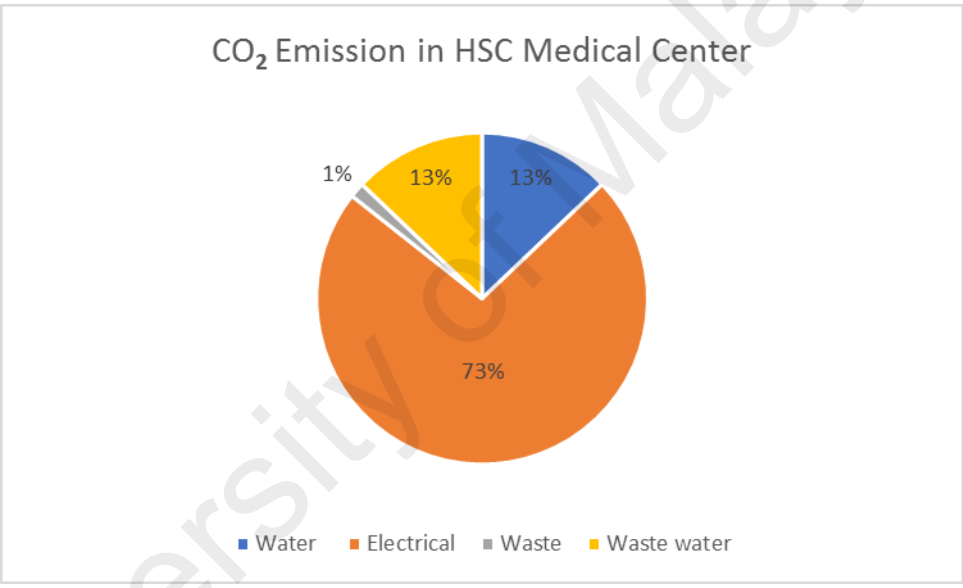


Figure 4.8: CO_2 Emission in HSC Medical Center

4.7 CP Option Generation

During data collection, usage per month was captured. Cleaner production option are recommended in Table 4.9. Cleaner production is studied on the main elements including energy efficiency improvement, water consumption reduction, general and clinical waste management as well as workers safety and productivity. Details of each CP option will be further discussed in the next chapter.

Table 4.9: CP Option Recommendation

No	CP Option	Recommendation	Reduction
1	Electricity	• Review AHU operation • Use energy saving bulbs • Increase temperature 18^0C to 24^0C • Regular maintenance to ensure efficiency of machine • Faster processing time	None 31% reduction (A) 48 % reduction (B) None None
2	Water Consumption	• Use water valve to prevent water wastages	13% reduction (C)
3	General waste	• Waste segregation according to their category and recycling	50% reduction (D)
4	Clinical waste	• Substitution to recyclable item	50% reduction (E)

Basis of calculation is explained further in Appendix D

4.8 Feasibility Analysis of CP Options

4.8.1 Option 1: Increased Temperature of Aircond from 18^0C – 24^0C

As the weather is getting warmer due to global effect, increase of air-conditioner usage indirectly contribute to more emission of hot air to the environment. Normally minimum setting is between 16^0C – 18^0C and this will lead to high energy consumption. One thing that can be observe is that some workers are wearing sweater to combat working in the cold air. These show that different people have different metabolic rate. Despite of promoting more energy saving purpose, it will also lead to a better efficiency among the personnel for a better productivity. But this cannot be done to all rooms as some of them have machines that needs constant temperature to ensure from faulty. So places to implement this is at the waiting area and to the room that is less occupied when the examination is done.

Table 4.10: Feasibility Analysis of Option 1

Electricity saving (kWh/month)	Carbon emission reduced (kg/Co_2month)	Cost Saving RM/month
9.6×10^3	6.4×10^3	3551

4.8.2 Option 2: Substitution of Water Valve

Average usage is 3771 m^3/month. When modification is done by installing check valve, average water usage reduces to 2865 m^3/month. It is because by using fix hand triggers it can control the water flow and pressure. Besides that, using of a smaller pipe can lower the flow rate comparing to the bigger piping.

Table 4.11: Feasibility Analysis of Option 2

Water saving (m^3 /month)	Carbon emission reduced (kg/Co_2month)	Cost Saving (RM/month)
506	343	1153

4.8.3 Option 3: Recycle of Waste Water for Cleaning Purpose

At HSC, cleaning is regularly done as often as every 2 hours. This is because, cancer treated patient also comes here to seek treatment. Therefore, due to low immunity, cleanliness is done to ensure comfort to them. Despite of regular cleaning times, it is advised to reduce the amount of cleaning time from 5 times to 3 times daily.

Table 4.12: Feasibility Analysis of Option 3

Waste water (m^3 /month)	Carbon emission reduced (kg/Co_2month)	Cost Saving (RM/month)
715	485	1630

4.8.4 Option 4. Recycle of Domestic Waste

Ideally paper and carton boxes can be recyclable that can becoming another source of income. Compactor machine is very user friendly and when it has been compacted, it can be send to the recycle center. For solid waste, it can be reused before finally disposing it. Example use of plastic cup are effective ways of recycling rather than paper cup which is can add up to total carbon emission in the premise. By reducing the wastage through proper segregation, it will help to reduce the waste volume generated in the dustbin. Convert the waste to recyclable waste will generate extra profit to the

company. Food waste are directly collected into a designated bin and sold to contractor for further process.

Table 4.13: Feasibility Analysis of Option 4

Waste saving (kg /month)	Carbon emission reduced (kg/Co_2month)	Cost Saving (RM/month)
156	581	468

4.8.5 Option 5: Substitution of Recyclable Clinical Waste

Through substitution such bed-pan linen, urine containers and stoma bags it can helps to reduce the cost and also helps to increase the return of investment. This has to come with a proper segregation so that waste that can be recycle are not mix together with the ones that is already contaminated.

Table 4.14: Feasibility Analysis of Option 5

Clinical waste saving (kg /month)	Carbon emission reduced (kg/Co_2month)	Cost Saving (RM/month)
27	15	80

4.8.6 Option 6: Installation of Equipment Power Factor

Improvement of power factor can also be done to prevent power loss from the end user. Causes for low Power Factor is due to inactive in nature, with winding or coil inside. It mostly happens at air-conditioners, fluorescent lights, etc. listed are some ways to improve Power Factor

1. Avoid operation of equipment above its rated voltage
2. Replace standard motors with energy-efficient motors.

3. Install Power Factor correction capacitors in the AC circuit panel. It can help to enhance the Power Factor to 95% and above.

Advantages of equipping Power Factor

1. Less Kilo-Watt (KW) are consumed in the daily operation, thus reduced monthly electricity bill to TNB
2. Increase system capacity and reduce system loss. Therefore, it is possible to increase load in the present electrical system
3. Increase voltage thus increase the efficiency of the electrical equipment.

4.8.7 Option 7: Installation of LED Bulb Lighting

LED (Light Emitting Diodes) are small, solid light bulbs which are extremely energy efficient and long lasting. LEDs operate differently than traditional incandescent light bulbs. This makes LEDs far more rugged and durable than traditional incandescent light bulbs. LED technology also offers many additional advantages over incandescent, neon and compact fluorescent lighting devices - such as exceptionally longer life span (60,000 hours), enormously lower energy usage (90% more efficient), reduced maintenance costs and higher safety. LEDs are currently being used for a wide variety of applications such as: residential lighting, aerospace, automotive, aviation, electronic instrumentation, entertainment and safety & transportation.

Table 4.15: Feasibility Analysis of Option 7

Electricity saving (kWh/month)	Carbon emission reduced (kg/Co_2month)	Cost Saving (RM/month)
$6.1x10^3$	4.1×10^3	1517

4.8.8 Option 8: Conduct Training on Energy Saving

Management should take an initiative to promote training program for staff that focus on energy saving policy. The content should involve on how to conserve energy, ways to do it and what are the mutual benefit that can be gained. On the long-term goal, it can help to save the environment for our future generation. Related training skill may also be conducted towards sustainability of the program.

4.9 Other options: Safety Aspect

It is important to ensure that hazard is eliminated or risks are minimizing at work place. A safe system and workflow shall comprise fully documented hazard precautions and safe working conditions throughout the whole facilities. This includes a safe operating procedure in a written system, proper step by step instruction on how to perform a task diligently. Component and subfield of the safe operating procedure shall include:

- To plan work guideline to complete each activity
- Safety measures to be taken 'before', 'during' and 'after' performing the task
- Emergency procedure including medical aid and what should be done next
- PPE and safety equipment to be utilized when performing out the task.

Safe work practice provides a sustainable safer working environment by maintaining:

- Good housekeeping and personal hygiene
- Safe storage and disposal of hazardous equipment
- Personal exposure limit through job rotation or limit working hour.

4.10 Summary of CP Options Evaluation

Electricity saving

Table 4.16 Cost Analysis Electricity Usage Per Month

Component	Consumption (kWh/Units/Month)	Savings (RM)	CO_2 reduced (kg/CO_2)
Air Conditioner	17×10^3	6260	5634
Lighting	6.1×10^3	2264	4100
Computer Desktop	2.5×10^3	1354	2578
Others (Machines)	2.3×10^5	88117	79305

By changing the temperature for air conditioner from 18^0C to 24^0C can helps to save up to 15% of yearly usage. All of the implementation does not require any investment and the ROI is immediate. The only cost needed is to change from fluorescent light to LED bulb that shows significantly 50% of reduction and it requires only a low budget of investment. Other than that, is to maintain the regular maintenance service which is done once a year.

Water saving

Table 4.17 Cost Analysis Water Usage Per Month

Component	Savings (RM)	CO_2 reduced (kg/CO_2)
Recycled	164.40	49
Installation of water valve	1153	343

Through installation of water valve, it can help to reduce over usage of water and also reduce wastewater generation. Therefore, treatment cost also reduced

Waste saving

Table 4.17 Cost Analysis Waste Generated Per Month

Component	Savings (RM)	CO_2 reduced (kg/CO_2)
Recycled	305	377
Segregation	4512	557

Tables above shows summary of carbon footprint reduction using cleaner production option. Food waste shows highest reduction which is up to 50% reduction of yearly usage. This is because of recycled and reuse method and no investment is needed to implement this option.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Cleaner production audit had been conducted in the selected medical center to identify any possible ways to reduce carbon footprint emission using cleaner production strategy. It was divided into 3 areas which is energy efficiency, water consumption and waste generation reduction. This study shows, large amount of CO_2 emission comes from electricity consumption (73%), followed by water consumption (13%), waste water (13%) and waste generation (1%). Current total of carbon emission for the premise is 2.07×10^5 tonne/year.

Cleaner production strategy was implemented and few option have been taken into consideration such as increase of energy efficiency, and energy saving activities. Other cleaner production option that was implemented were improved process control, equipment modification, conduct training program, reuse and recycling for waste reduction. Subsequently these options can generate expected saving of RM 3660/ month and CO_2 emission reduction of 0.4 ton CO_2/month.

The results of the study show implementation of cleaner production option and strategies gives impact on carbon footprint emission in terms of reducing carbon emission as well as cost. The implementation of suggested cleaner production options is expected to benefit the premise through total saving of RM 43,9500 / year. Cleaner production proves that zero or low-cost CP option could reduce electricity consumption and CO_2 emission. Implementation of cleaner production strategies can be recommended to other healthcare sector which will help managing energy and water consumption as well as waste generation reduction.

5.2 Recommendation for Future Work

For continuous process, implementation and monitoring, some action below is recommended to the administration for further action

1. Detail cost analysis study should be conducted to evaluate the feasibility of implementing suggested CP options.
2. Detailed study on energy saving in medical centers should be conducted to identify potentials to reduce energy consumption.
3. Implementation of CP strategy to other medical centers in Malaysia.

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