WATER LEAKAGE IN UNIVERSITI TEKNOLOGI PETRONAS (UTP) FROM TAPS TO CARBON DIOXIDE (CO_2) EMISSION

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UNIVERSITI TEKNOLOGI PETRONAS

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Dissertation submitted in partial fulfilment of

the requirement for the

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(KABILAN A/L MUTHUSAMY)

ABSTRACT

This report shows the water leakage problem in Universiti Teknologi Petronas and its impact to the amount of energy which is wasted due to the water leakage. Water leakage due to poor maintenances is a major issue in every building around the country and in Universiti Teknologi Petronas the issue had reached a critical stage. Domestic water which is acquired form a 3rd party which treats the water and supply to UTP is bought at certain stipulated price. The water outlet especially water taps which are leaking and allows continuous water flow. This creates constant flow of wastage of resources in UTP.

These report shows the amount of water is being wasted in UTP campus in per minute basis which is crucial for our research. Data collection was done from point to point by measuring the amount of water being leaked at each point using measurement tools. Site visits were done accordingly based on the schedule in Gantt chart. Interviews were conducted with relevant personals who are involved in water facility management and handling to support data gathering process. Interviews also was conducted with personals involved in energy supply for UTP, for data collection on analysis purposes

Due to the increment number of students in Universiti Teknologi PETRONAS, the accommodations are also increased. This directly had resulted in the increased need of water .Treated water supply and demand comes with an energy usage tag. All activities related to water treatment and supply such as treating raw water, pumping, filtering, storage requires the usage of energy. This directly results in the release of greenhouse gas, more specifically Carbon dioxide. Wastage of water due to poor maintenance and services contributes for the loss of energy, increased in cost and also increase in Carbon Dioxide emission.

These problems can be avoided if proper maintenance is done routinely in the campus. A schedule should be prepared for maintenance personals to constantly monitor the water outlets in UTP. The minor repairs should be tackled from time to time to avoid more wastage and increased maintenance cost. A permanent vendor with contractor licence of class F can be appointed to tackle the water leaking problems in campus. A minor allocation of budget can help to eliminate leakage problems. Recommendations such as stakeholder's awareness and appointment of extra maintenance personals should be considered in avoiding the main issue. When the major issue is tackled the correlating problems such as energy wastage and carbon dioxide (CO_2) emission can be avoided.

Contents

List 0f Figures

List of Table

CHAPTER 1

1.0 INTRODUCTION

1.1 Background Study

Water is an essential element for survival human population. It is estimated that 2.5% of the total water reserve in the world considered as fresh water which and being used for daily human activities and consumption (Nawawi, Hamzah). The balance of the water available is considered to be salt water which is unsuitable for human activities. Water is known as H_2O where it consists of 2 parts of hydrogen and one part of oxygen. Pure water or distilled water is considered to be a universal solvent and has a pH value of 7 to 7.1.

Fresh Water in general typically requires treatment prior to supply for demand. To supply for demand water needs to be pumped and pressurised to reach the clients. All activities related to water treatment and supply such as treating raw water, pumping, filtering, storage requires the usage of energy.

This directly results in the release of greenhouse gas, more specifically Carbon dioxide. Energy in Malaysia usually obtained from gas turbine power plant which has significant carbon foot print. Leakage of treated water from domestic water outlets such as faucets, toilet bowl, shower heads n etc significantly contributes for wastage of energy and increase in carbon dioxide emission. This causes loss of energy for treatment and for pumping.

Usage of energy had direct cost usage, thus wastage of water directly affect cost efficiency. In Malaysia the cost of usage of energy is around 21.80sen/kWh to 57.10sen/kWh per unit for normal tariff (TNB, 2014). In general, wastage of water due to poor maintenance and services contributes for the loss of energy, increased in cost and also increase in Carbon Dioxide emission.

Graph shows the projection of Water Demand Trend of Various Sector in Malaysia

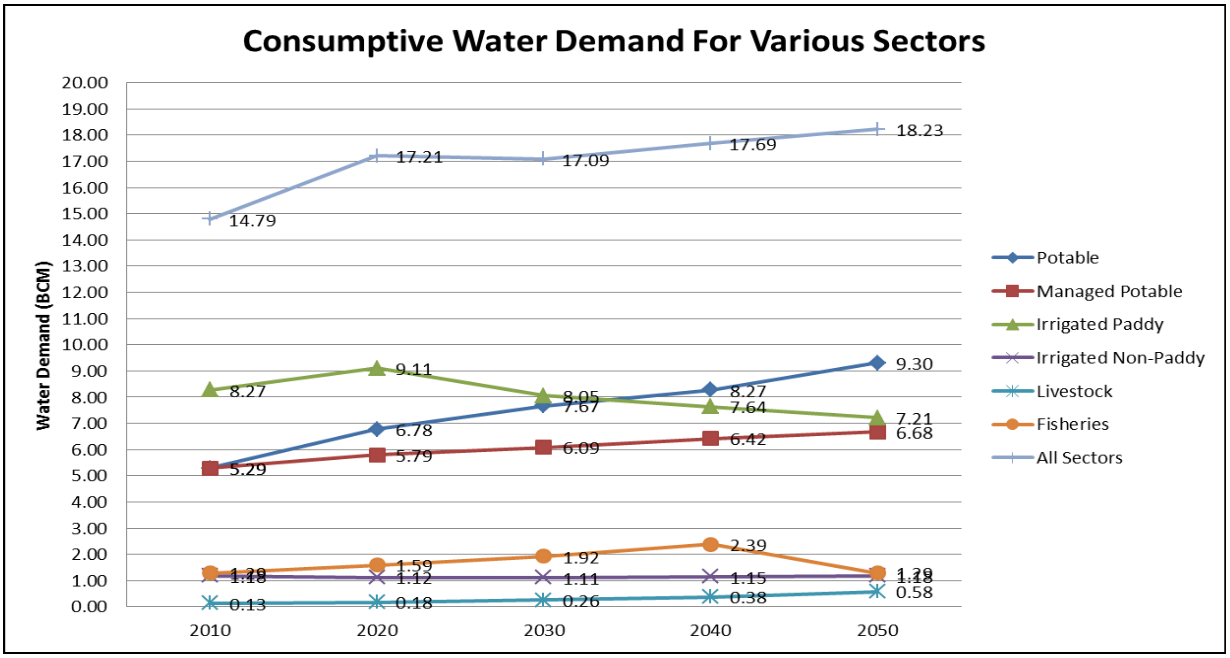

Figure 1: Projection of Water Demand Trend of Various Sectors in Malaysia

Source: NWRS 2011

1.2 Problem Statement

In Universiti Teknologi PETRONAS the lack of in monitoring system and proper maintenance of water outlets had caused widespread leakage problem around the campus. The water outlet especially water taps are leaking and allows continuous water flow. Water leakage due to faulty water outlets such as taps, shower heads are very common in Universiti Teknologi PETRONAS restrooms, bathrooms and cafeterias. Overall this wastage is represents the energy loss on the effort for treatment and supply which directly implicates the increased CO_2 emission.

1.3 Objectives

The objective of the project is to develop data gathering and analysis program starting from the volume estimation of total amount of water wasted to the level of estimation of amount of CO_2 emission due to the water wastage and continued outflow of treated water. The following objectives are to be met for the proposed study;

1) To monitor and measure the amount of treated water wasted in Universiti Teknologi PETRONAS buildings and establish statistical data of energy wasted.

2) To calculate the energy wasted and correlate with the amount CO_2 emission cause due to the treated water wastage in Universiti Teknologi PETRONAS.

3) To estimate the total monetary cost incurred as lost due to leakage from the total consumption in Universiti Teknologi PETRONAS .

1.4 Scope of Study

The scope of study involves the estimation of volume flow rate from leakages in UTP. The Study also involved on the data gathering of the total period of breakage or leaking on each leaking outlets to estimate total lost incurred on weekly, monthly and yearly period basis. Based on the date gathered calculations done to estimate the amount of energy used based on the data gathered on the leakage. The scope of study also included the calculation based on the energy usage estimation, where estimation on CO_2 emission can be obtained. The scope of study also includes the observation on data correlations between water wastage in a Tap to the CO_2 emission caused. The study also concentrates on leakage monitoring for the period of 6 months which starts from early March 2014 till end of August 2014. The data gathered only comprises leakage from male toilets only, disregarding female toilets and washroom due to hindrance.

1.5 Feasibility of Project

The project proposed is subjected for completion in a time frame of 28 weeks (FYP 1 & FYP 2). With the current availability of equipments and facilities in the university, the time allocated is fairly enough to produce results. The Gantt chart drafted (shown in page 19, Chapter 3) features all the activities planned for the specific time frame. It is also was done to ensure that the project works does not fall behind schedule and to meet the datelines specified by the course committees. This also includes 6 month of monitoring period of water leak points.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Literature review

Universiti Teknologi PETRONAS is currently the main university in Malaysia concentrating on the engineering prospects of energy business and Oil & Gas Industry. As the demand in industry increases more students pursue their studies in Universiti Teknologi PETRONAS. Due to the increment number of students in Universiti Teknologi PETRONAS, the accommodations are also increased. This directly had resulted in the increased need of water (Abd. Razi, Naizaitul Husna, 2004). Treated water supply and demand comes with an energy usage tag. Increase in demand and supply needs for treated water increases the usage energy required for the supply of the demand.

According to Veolia Water (n.d), in 20 years time, the world demand for water will rise by 40 % and in developing countries the demand is expected to be doubled. Due to this fact, the availability of water in order to cater the world population will be key factor for global growth in future. In certain part of the world, especially in less develop and developing countries, millions of people still do not have water supply because there is lacking in infrastructure.

Somehow, in different part of the world, water leakages in distributed water network that can exceed to 50 % are major issues that contribute to the growing pollution (Veolia Water, n.d). Thus, water supplies should be conserved wisely.

As previous study in nationwide of United States estimate that U.S. water-related energy use is at least 521 million MWh a year—equivalent to 13% of the nation's electricity consumption. While it appears to be a conservative estimate of water-related energy use, other findings also suggest that the carbon footprint currently associated with moving, treating and heating water in the U.S. is at least 290 million metric tons a year.

The CO_2 embedded in the nation's water represents 5% of all U.S. carbon emissions and is equivalent to the emissions of over 62 coal fired power plants (Sattenspiel and Wilson, 2009). In addition, to process the water, huge amount of energy is needed, which in turn produce large amount of carbon emissions.

A comprehensive mathematical model is developed by a group of engineers for this study can be used to compare the estimates of on-site and off-site CO_2 emissions, from water treatment plants (WTPs). When 200,000 m(3) of raw water at 10 NTU (Nepthelometric Turbidity Unit) was treated by a conventional WTP to 0.1 NTU using aluminum sulfate as a coagulant, the total CO_2 emissions is estimated to be 790 ± 228 (on-site) and $69{,}596 \pm 3950$ (off-site) kg CO_2e/d (Kyung D, et al. 2013) .

The total energy consumed could be considered incurring losses if the demand end of the water supply-demand chain is wasting the treated water. The wastage of the treated water is most likely to be highly contributed due to poor maintenance and services of the water outlets such as faucets, taps, toilets, showers and etc. Leakage occurs in all distribution and supply systems, and is governed by the condition of the pipes, the operating pressure and how well leakage problems are monitored and addressed.

From an economic perspective, the cost of any measures to reduce leakage must be less than the cost to produce the water from another source. Target levels for reducing leakage are set that balance the needs of water users and the environment (Killeen, 2008). The emission factors for water supply and treatment in Table 52 have been sourced from Water UK (2008, 2009, 2010) and are based on submissions by UK water suppliers. Water UK represents all UK water and wastewater service suppliers at national and European level.

Life-cycle GHG conversion factors for water: 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors.

Table 1: Life-Cycle GHG Conversion Factors for Water

Fuel Used	**Units**	**kg CO_2 per unit**		
		2007/08	**2008/09**	**2009/10**
Water Supply	million litres	276	300	340
Water Treatment	million litres	693	750	700

Source: Water UK (2008), Water UK (2009) and Water UK (2010). Water UK

CHAPTER 3

3.0 METHODOLOGY

3.1 Flow Chart

3.1.1 Overall Final Year Project Flow chart

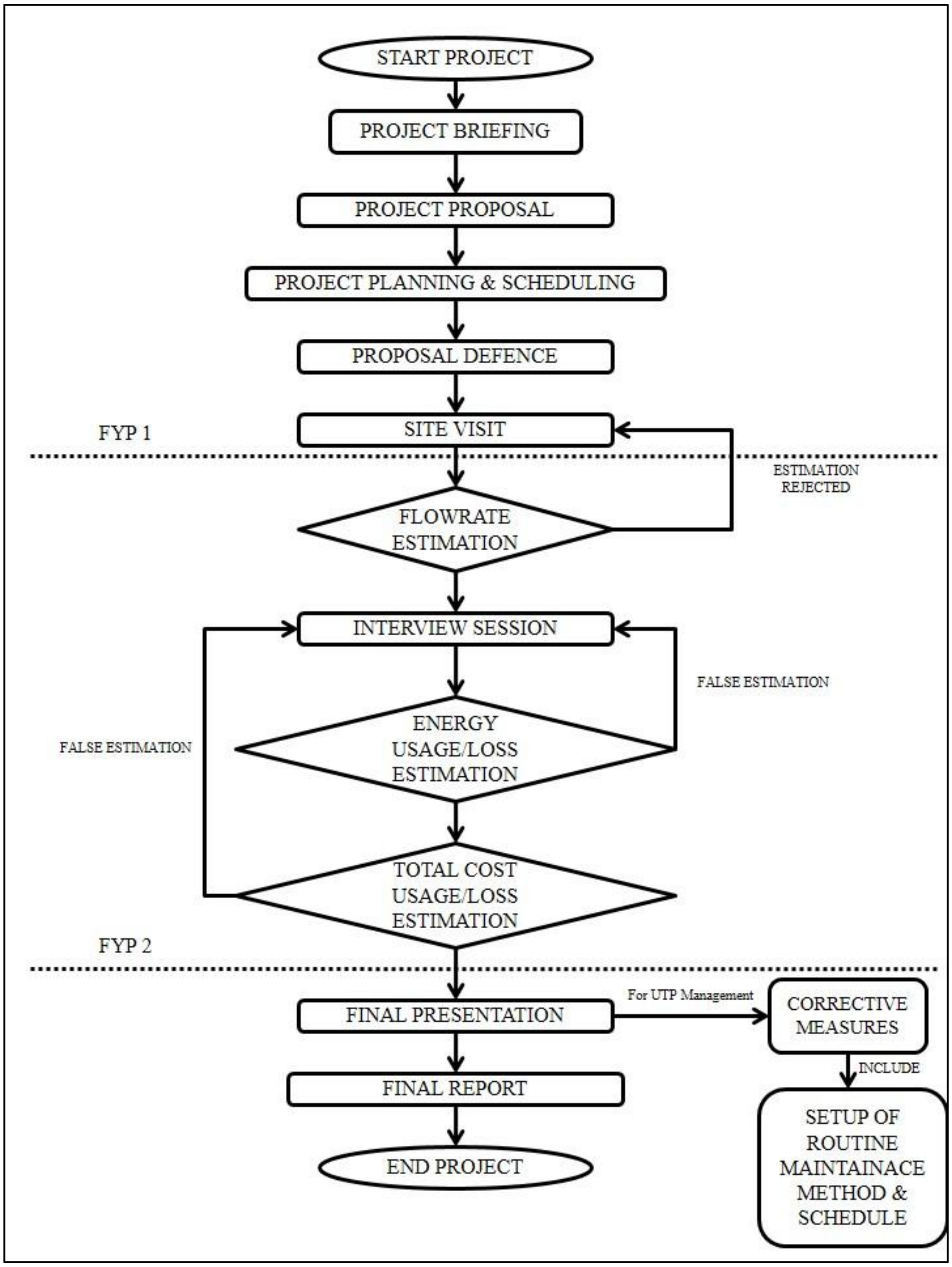

Figure 2: Overall Final Year Project Flow Chart

3.1.2 Site Visit Flow chart

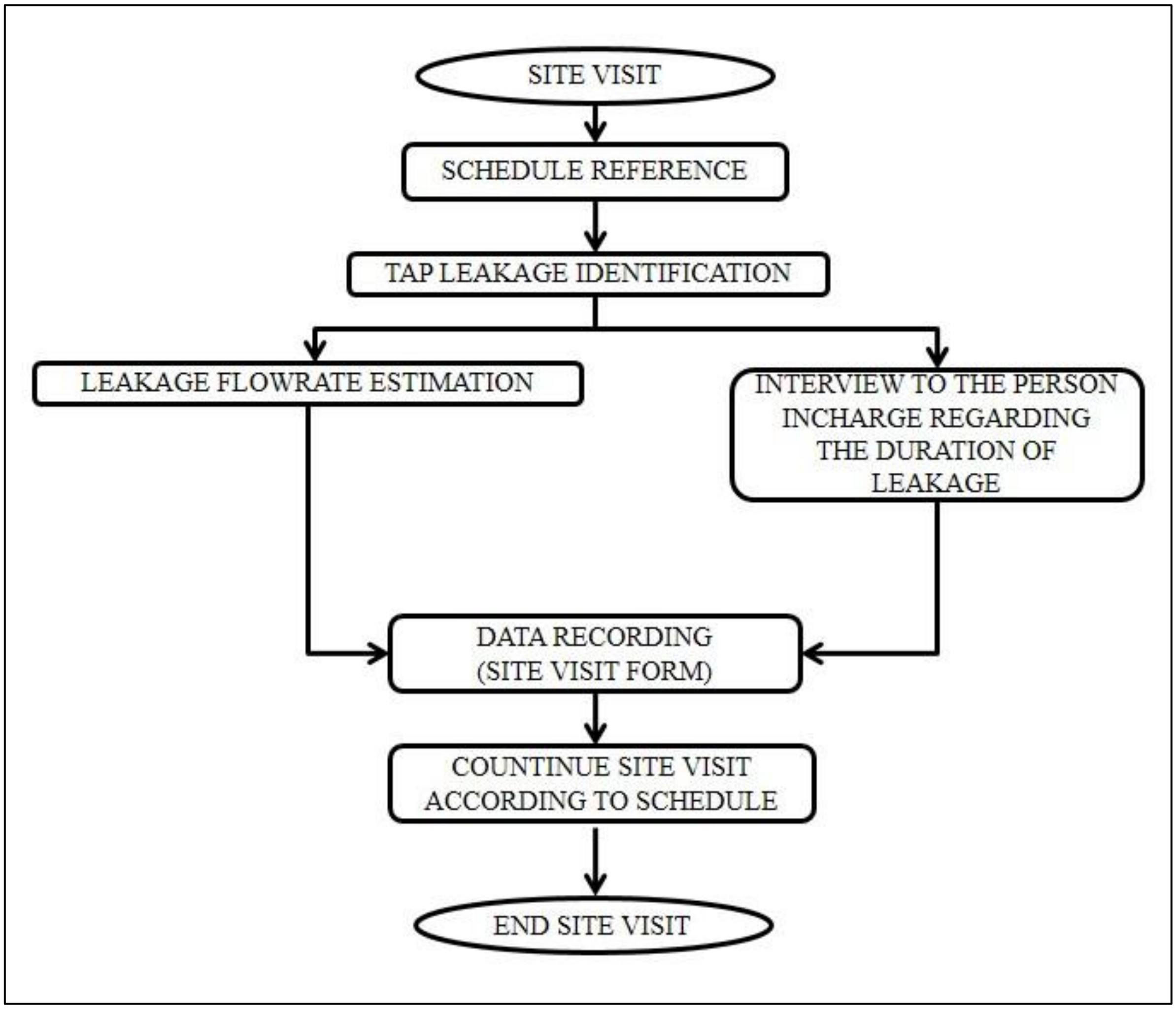

Figure 3: Site Visit Flow Chart

3.2 Equipments/tools

Equipments/tools to be used for site visit data collection.

1) 5 Liter Container

   -To collect the wasted treated water from the water outlet.

2) Plastic Tubing

   - To channel to waste water from the funnel to the container

3) Funnel

   - To funnel the waste water from water outlet to the container

4) Clamp

   - To hold the funnel at the water outlet

5) Time watch

   - To measure the time taken for the 5 liter container to fill up

6) Site visit Form

   - To record datum

UNIVERSITI TEKNOLOGI PETRONAS
MECHANICAL ENGINEERING DEPARTMENT

FYP SITE VISIT DATA COLLECTION FORM

WATER OUTLET LOCATION : ______________________________

____

PERSON IN CHARGE : ______________________________

DURATION OF LEAKAGE : ______________________________

TIME TAKEN TO FILL 5liters VESSEL : (i) READING 1 : ____________
(i) READING 2 : ____________
(i) READING 3 : ____________
AVERAGE TIME : ____________

AVERAGE FLOWRATE = (VOLUME / AVERAGE TIME)

= 5 liter / ____________

= ____________________

Figure 4: Sample of Site Visit Form

3.3 Gantt Chart

Department	Training activities	Week No																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Water Leakage in Universiti Teknologi PETRONAS From Taps To CO_2 Emission.	Project Selection & Finalization																														
	project Proposal Preparation & Proposal Defence																														
	project Schedule & Equipment Preparation																														
	Data Collection (Site Visit)																														
	Interim Report																														
	Progress Report																														
	Pre-SEDEX																														
	Final Dissertation & Viva																														

LEGEND	
	FYP 1
	FYP 2
	COMPLETED
	IN PROGRESS

CHAPTER 4

4.0 RESULT AND DISCUSSION

4.1 Leakage Flow Rate

Table 2: Data Collection of Flow Rate from all Leakages

No	Location	Leak Flow rate (liter/minute)	Leak Duration(months)	Remarks
1	Block 19	0.02	-	Roof leaking
2	Block 19	3	-	water tank leaking
3	block 18	0.015	8	
4	block 17	0.027	4	new leak
5	block 17	0.016	-	old leak, stained
6	block 17	0.5	3	
7	block 17	0.035	1	
8	block 17	12	8	leak observed by Dr.Hussain
9	block 16	0.13	3	overflow
10	block 16	0.3	3	direct leakage of urinal
11	block 16	0.02	2	no stains
12	block 16	0.02	6	stained floor
13	block 15	0.33	5	
14	block 15	0.29	7	
15	block 15	-	-	water tank leaking
16	block 15	0.03	-	
17	Block 14	0.4	6	urinal malfunction-stained
18	Block 14	0.12	8	OKU toilet overflow
19	Block 14	0.06		stained - OKU
20	Block 14	0.017	5	
21	Block 14	0.016	4	OKU toilet overflow
22	Block 13	-	-	Tank Leaking- Sound- No Data
23	Block 13	0.3	7	OKU toilet overflow
24	Block 13	-	8	Wall Piping Leakage- No Data
25	Block 13	0.07	2	OKU toilet overflow
26	Block 13	0.12	12	Stained Leak
27	Block 13	0.05	8	OKU toilet overflow
28	Pocket C	0.4	-	Urinal malfunction (out)
29	Pocket C	12	-	Toilet Flush Malfunction(in)
30	Pocket C	12	-	Urinary Flush Malfunction(out)
31	Block 20	0.13	4	OKU toilet overflow

32	Block 20	0.073	3	OKU toilet overflow
33	Block 20	0.45	-	Toilet Pipe Malfunction
34	Block 21	0.0065	-	OKU toilet overflow
35	Block 21	0.0073	7	OKU toilet overflow
36	Block 21	0.3	-	Sink Pipe Malfunction
37	Block 22	12	12	Toilet Flush Malfunction
38	Block 22	0.6	4	Toilet Pipe Malfunction
39	Block 22	12	6	Toilet Flush Malfunction
40	Block 23	0.42	7	Stained Leak
41	Block 23	0.5	-	Urinal Malfunction
42	Block 23	0.058	-	OKU toilet overflow
43	Block 23	0.4	3	Urinal Malfuntion
44	Block 23	0.18	-	OKU Toilet Flush Malfunction
45	Block 5	12	4	Toilet Flush Malfunction
46	Block 5	12	4	Toilet Flush Malfunction
47	Block 5	0.062	-	OKU toilet overflow
48	Block 5	0.081	4	OKU toilet overflow
49	Block 5	0.12	4	OKU toilet overflow
50	Block 4	0.02	-	OKU toilet overflow
51	Block 4	0.072	-	OKU toilet overflow
52	Block 3	0.12	3	-
53	Block 2	12	1	Toilet Flush Malfunction
54	Block 2	0.03	5	Stained
55	Block 1	0.045	5	old leak, stained
56	Pocket D	12	6	Toilet Malfunction
57	Pocket D	0.3	6	Urinal Malfunction(out)
58	USM	0.06	3	Canteen Sink
59	USM	0.048	5	Lecture Hall Toilet
60	Village 5	0.05	3~8	Toilet Sink
61	Village 5	0.12	3~8	Pantry Sink Pipe
62	Village 5	0.21	3~8	Toilet
63	Village 5	0.18	3~8	Toilet Sink
64	Village 5	0.3	3~8	Toilet Sink
65	Village 5	0.48	3~8	Toilet Sink
66	Village 5	0.14	3~8	Toilet Sink
67	Village 5	0.19	3~8	Toilet
68	Village 5	0.055	3~8	Pantry Sink Pipe
69	Village 5	0.36	3~8	Pantry Sink Pipe
70	Village 5	0.24	3~8	Pantry Sink Pipe
71	Village 5	0.075	3~8	Toilet

72	Village 5	0.14	3~8	Toilet
73	Village 5	0.13	3~8	Toilet
74	Village 5	0.09	3~8	Toilet
75	Village 2	0.081	1~2	Pantry Sink Pipe
76	Village 2	0.055	1~2	Toilet
77	Village 2	0.075	1~2	Shower Head
78	Village 2	0.26	1~2	-
79	Village 2	0.03	1~2	Toilet
80	Village 2	0.95	1~2	Shower Head
81	Village 2	0.048	1~2	Pantry Sink Pipe
82	Village 3	0.3	4~7	-
83	Village 3	3	4~7	Toilet Flush Malfunction
84	Village 3	7	4~7	Flush Malfunction
85	Village 3	0.65	4~7	-
86	Village 3	0.12	4~7	-
87	Village 3	0.043	4~7	-
88	Village 3	0.53	4~7	Flush Leak
89	Village 3	0.018	4~7	-
90	Village 3	0.035	4~7	Toilet Sink
91	Village 3	0.15	4~7	Pantry Sink Pipe
92	Village 3	0.065	4~7	Pantry Sink Pipe
93	Village 3	0.087	4~7	Pantry Sink Pipe
94	Village 3	0.073	4~7	Pantry Sink Pipe
95	Village 3	0.18	4~7	Pantry Sink Pipe
96	Village 4	0.35	4~7	Shower Head
97	Village 4	0.065	4~7	Shower Head
98	Village 4	0.9	4~7	Shower Head
99	Village 4	0.039	4~7	Shower Head
100	Village 4	0.068	4~7	Shower Head
101	Village 4	0.4	4~7	Shower Head
102	Village 4	0.18	4~7	Toilet Sink
103	Village 4	0.033	4~7	Pantry Sink Pipe
104	Village 4	0.043	4~7	Pantry Sink Pipe
105	Village 4	12	4~7	Toilet Flush Malfunction
106	Village 4	0.06	4~7	Toilet
107	Village 4	0.077	4~7	Toilet
108	Village 4	1.2	4~7	Toilet Sink
109	Village 4	0.045	4~7	Toilet Sink
110	Village 4	0.81	4~7	Pantry Sink Pipe
111	Village 4	0.067	4~7	-

112	Village 4	0.87	4~7	-
113	Village 4	12	4~7	Toilet Flush Malfunction
114	Village 4	0.026	4~7	Toilet Pipe Malfunction
115	Village 4	0.42	4~7	Sink
116	Village 4	0.067	4~7	Sink
117	Village 4	0.53	4~7	Sink
118	Village 4	0.031	4~7	Pantry Sink Pipe
119	Village 4	0.33	4~7	Pantry Sink Pipe
120	Village 4	12	4~7	Toilet flush Malfunction
121	Village 4	0.05	4~7	Toilet Sink
122	Village 4	0.048	4~7	Pantry Sink Pipe
123	Village 4	0.096	4~7	Toilet Pipe Malfunction
124	Village 4	12	4~7	Toilet Malfunction
125	Village 1	0.14	1~2	Pipe
126	Village 1	0.33	1~2	Flush Leaking (right)
127	Village 1	12	1~2	Toilet Flush Malfunction(right)
128	Village 1	0.33	1~2	Flush Leaking (right)
129	Village 1	0.15	1~2	Pipe Continuous Flow (left)

Table shows the compilation of data collected regarding the flow rate of leaks in all the water outlets around Universiti Teknologi PETRONAS

The data above shows the data collected from the toilets which were inspected during the site visit. The total leak flow rates which can be calculated from the 129 points are 202.6338 liters per minute is currently being wasted in all over Universiti Teknologi Petronas. The flow rate of all the leaks is 202.6 Liters/Minute which translates to 0.2026m^3/minute. All the leaks were monitored for 6 months as stated on the scope of study. Above data shows that overall, in average, each leak is being faulty for a period of 6 months. On this paper we consider the 6 months period as the whole leaking period for all the leak point because monitoring was done periodically at the 129 leak points.

4.2 Site Visit Datum

4.2.1 Property Management and Maintenance Department

Person in Charge = Mr. Noorhazrin B. Basri (Mechanical Maintainance)

LAP Account Number for UTP	= SPT002124
Tariff Code	= 21
Water Tariff Rate	= RM 1.61/m^3
Average Monthly water Usage of UTP	= 113000 m^3
Average Monthly Cost	= RM 183000

Pumps involved In Water Supply for UTP Domestic Usage (Details)

Cold Water Pump	= 2 units
Brand	= Grundfos
Type	= Centrifugal Pump
Power Rating	= 30hp/22kW each pump
Flow rate capacity	= 115 cubic meters each pump
Pump Frequency	=50Hz each pump
Voltage Rating	= 415V each pump
Current Rating	= 39 Amperes each pump
Pump Head	= 45 meters

UTP water Supply flowchart

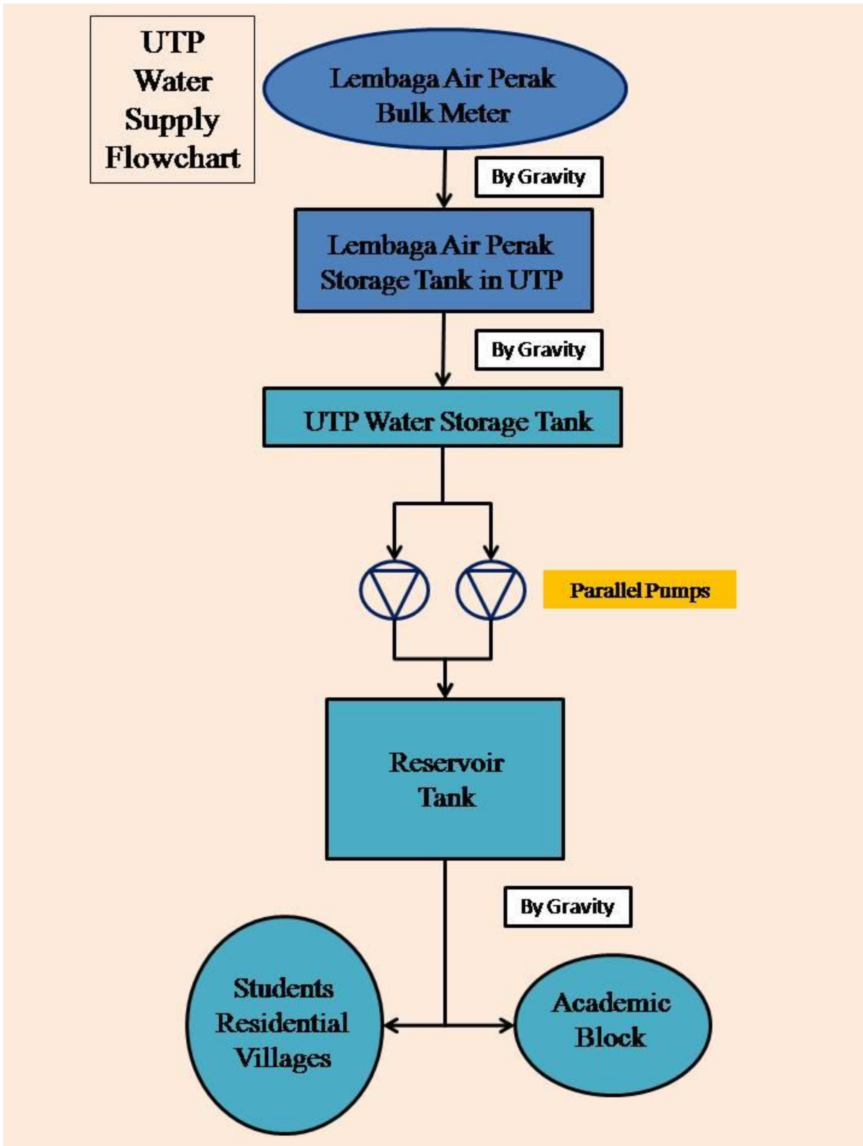

Figure 5: UTP Water Supply Flowchart

4.2.2 GAS District Cooling Plant (GDC) Universiti Teknologi PETRONAS

Person in Charge= Mr. Shahril-Technician

Plant Capacity	= 8.2 Mwatt
Turbine Type	= Gas turbines (2 units)
Plant Type	= Co-Generation Plant
	(Electricity + Air Conditioning-Chill/cold Water)
Average Power Generation	= 130000 kWh
Turbine Efficiency	= 0.85
Plant Consumption	= 662000 Gjoule
Overall Plant Efficiency	= 48.0 %
Fuel Used By Plant	= Methane CH_4
Fuel Supplier	= PETRONAS Gas Sdn.Bhd

4.2.3 More Site Visit Details

Figure 6: UTP Water Storage Facility

Figure shows LAP water storage facility which is located in UTP near new construction site of R&D offices. This tank receives direct Treated water from Lembaga Air Perak

Figure 7: UTP Water Tank Tower

Figure Shows water tank Tower which is located near the UTP Vice Chancellor Residents

Figure 8: Block O Water Storage Facility

Figure shows the water storage facility which is located near Block O of Old campus block

Figure 9: UTP GDC Plant

Figure shows the GDC Plant of UTP which is Co-Generation Natural gas Turbine plant which generates all the required energy to be used in UTP.

Figure 10: GDC Gas Supply

Figure shows the Natural Gas supply method to the GDC plant in UTP which includes a receiving station, valve station, and intake manifold from Gas Malaysia distribution.

4.3 Discussion

The data shows that the leaks flow rate from 129 points of leak in UTP. The point of leak of the place of leak which was inspected is overall UTP campus including academic blocks and certain part of the hostels. The amount of water being wasted is at an alarming rate. We consider the average faulty period of each leak point as in 6 months which is supported by the data which I had obtained from the interviews, cross checking during the research period and also my observations during the site visit. Using that datum and by doing further calculation we can show that, UTP has been wasting nearly 52 million liters of for the duration.

When translated, the amount is equivalent to 52000 m^3 of water. My field visit to the Lembaga Air Perak office in Seri Iskandar had informed me, the tariff rate for UTP is 161sen per m^3 which serves the water charges for bulk supply as they have provided storage tank in UTP. This water which is being wasted has direct result on the wastage of energy due to pumping, supply and storage activities. The amount of energy wasted which will be determined by the end of this project as certain field visits are yet to be carried in weeks after this report.

The CO_2 emission calculated by obtaining some raw data during the site visit and by correlating with the amount of energy is wasted. The data which need are the capacity of the GDC plant and Fuel value of the Natural Gas supplied to the GDC plant. As natural gas majorly comprises of methane, we use methane complete combustion equation for the CO_2 emission calculation. Using the data we are able to calculate amount of fuel used in kmol/hour and from that we are able to calculate on the amount of CO_2 emission released in the form of kg/day. Calculations and analysis are as follows below.

4.3.1 Water wastage graph analysis

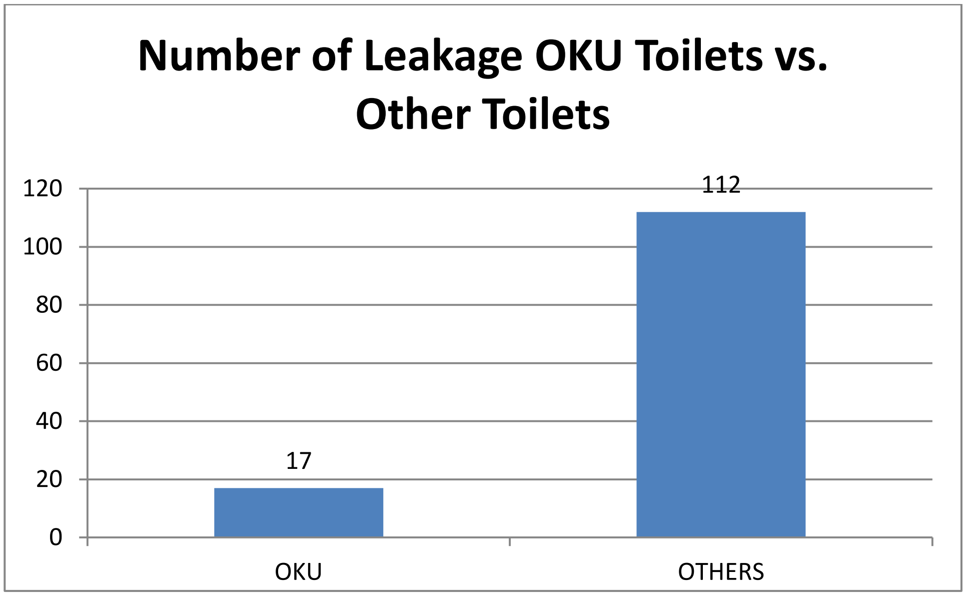

Figure 11: Number of Leakage OKU Toilets vs. Other Toilets

Graph above shows the number of OKU toilets and other toilets in UTP that experience water leakage. This graph clearly indicates that the number of other toilets that has leakage is higher compared to OKU toilets where OKU toilets are only 17 whereas other toilets are 112. This trend is probably due to the general number of OKU toilets is practically less than other toilets.

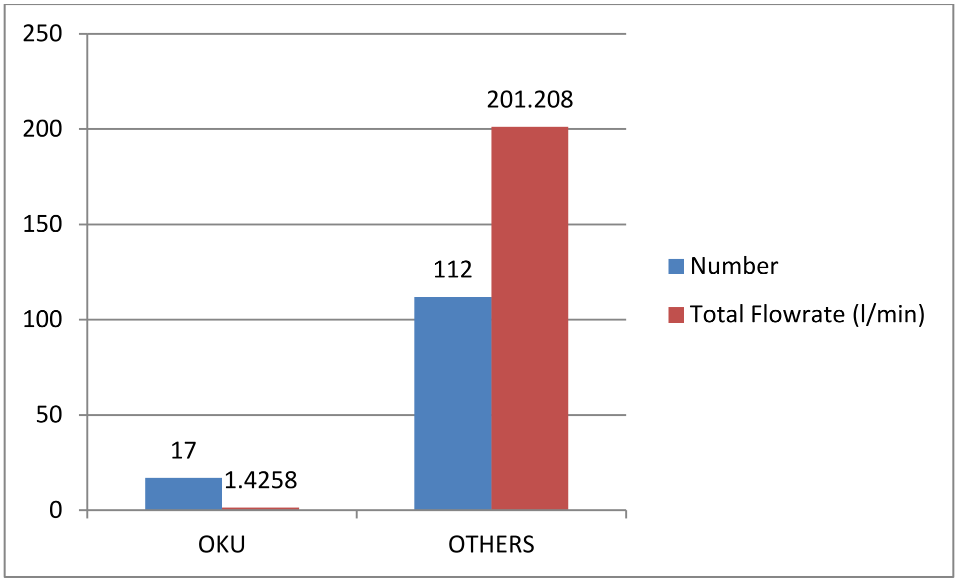

Figure 12: Number of Leakage Toilets with Flow Rate

On the other hand, graph above shows the refined number of OKU toilets and other toilets in UTP that experience water leakage together with the total flow rate of these toilets. From the graph, the total flow rate for OKU is 1.428 l/min while other toilet is 201.208 l/min.

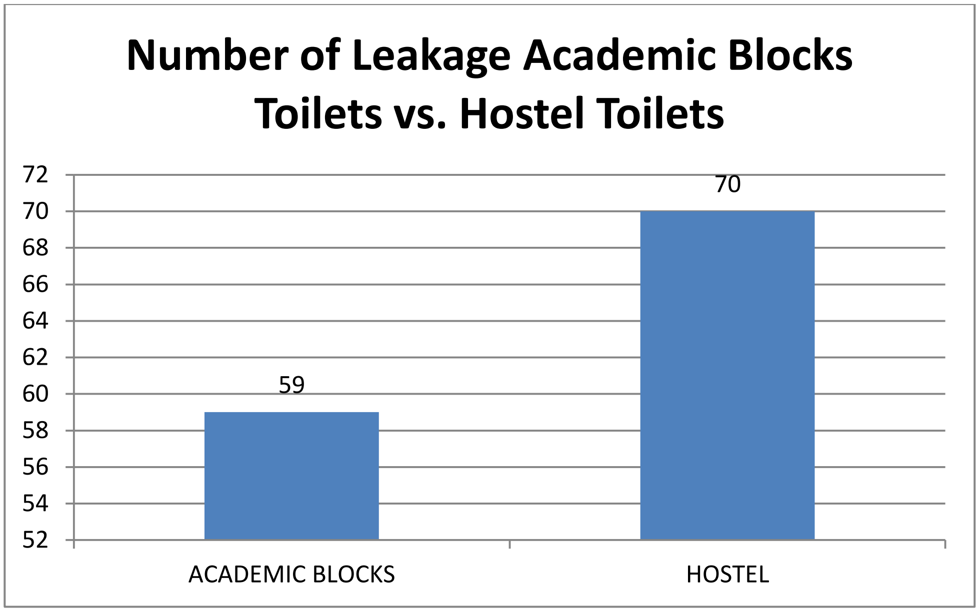

Figure 13: Number of Leakage Academic Block Toilets vs. Hostel Toilets

Graph above shows the number of toilets in academic blocks and hostel that has water leakage. This graph depicts that the number of hostel toilets that has leakage is higher compared to the number toilets in academic blocks with 70 and 59 respectively.

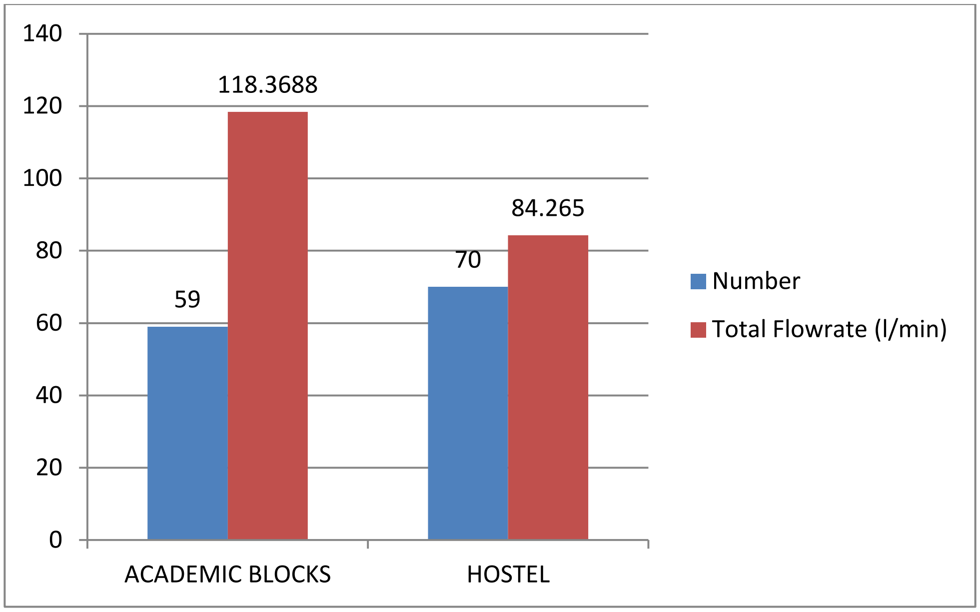

Figure 14: Number of Leakage Toilets with Flow Rate

On the other hand, graph above shows the number of academic toilets and hostel toilets in UTP that experience water leakage together with the total flow rate from these toilets. From the graph, the total flow rate for toilets in academic blocks is 118.3688 l/min while other toilets in hostel are 84.265 l/min. Despite the fact that the number hostel toilets is more by 11 compared to number of toilets in academic blocks, the flow rate of water wastage in hostel toilets is relatively lower than that of academic blocks. This might be contributed to the frequency and awareness of people using the toilet where the hostels toilets are much more visited by people thus, the leakage of any taps will be reported and will be fixed accordingly. The other factors that play a part in giving this particular trend is some of the toilets in hostel are newly renovated like the toilets in Village 1 and Village 2.

4.3.2 Cost Wastage analysis

Water wasted per minute	= 202.6338 liters/ minute
202.6338/1000	= 0.2026 cubic meters per second
Water wasted per hour	= 12.156 cubic meters per hour
Water wasted Per Day	= 291.744 cubic meters per day
Water wasted Per Month	= 8,752.32 cubic meters per month
Water wasted in average Default Period	= 52,513.92 cubic meters
Water Tariff Rate	= RM1.61
Cost Wasted per day	= RM469.71
Cost Wasted per month	= RM14, 091.24
Cost Wasted in Average Default Period	= RM 84,547.41

4.3.3 CO_2 Emission analysis

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Capacity of GDC Plant	= 8.4 MW	1 W = 1 J/s
So,	= 8400 KJ / s	
Fuel Value of Methane	= 891.1KJ / kmol	

Amount of Fuel Used = Capacity/ $\frac{Methane}{Natural\ Gas\ Fuel\ Value}$

= $\frac{kJ}{s}$ X $\frac{mol}{kJ}$ = mol/s

=8400 $\frac{kJ}{s}$ / 891.1 KJ / kmol

CO_2 = 9.4266 mol/s

= mol/s X molar mass

Molar Mass

CH_4 = 16

O_2 = 32

CO_2 = 44

H_2O = 18

= 9.4266 mol/s X 44

Emission by GDC plant = 414.77 g/s

= 414.77 g/s X 60 X 60 X 24

=35,836.12 kg/day

Percentage Energy for Pumps = 0.042%

CO_2 Emission caused = 0.042% X 35,836.12

= 15.16 kg/day

=15.16 kg/ day X 30

= 454.8 Kg/month

=454.8 Kg/month X Average Default Period (6Months)

= 2728.3 kg

4.4 Analysis (conclusion)

Total leak points measured	= 129 points
Total leak flow rate	= 0.2026 m^3/minute.
Average leak period	= 6 months
Tariff rate per m3of water	=RM 1.61 per m3
Electricity supplier	= GDC plant, UTP
Average energy Consumption by UTP per day	= 130000 kW
UTP monthly water consumption	= 113,000 m3

Pumps managed by UTP Property Management and maintenance department (PMMD)

<u>Pumps</u>

2 units Centrifugal Pump- at any given time 1 unit works, parallel pumping system

Flow rate	= 115m3/hour –each pump
Power Rating	= 30hp/22kW – each pump

Table 3: Summary of the Analysis

Criteria	1 month period	Average Default period (6months)
Total water leaked/wasted	8752.32m^3	52513.92m^3
Total energy wasted	1674kW (units)	10046kW (units)
Total CO2 emission	454.8kg	2728.8kg
Total cost wasted in purchasing Treated water	RM 14, 091.25	RM 84, 547.41

Percentage of water wasted from the amount of water consumed per month.

7.72 %

Percentage of cost wasted from the total cost of purchasing raw water from LAP per month.

7.73%

CHAPTER 5

5.1 CONCLUSION

The conclusion which we can obtain from the result and data is that the water wastage in UTP is at an alarming rate. Based on the proposal we had worked on, this project is fully completed and able to show the total amount of water is being wasted in UTP. The total amount of leakage is 0.2026 m^3 per minute and the analysis of the leakage is shown in Chapter 4 of this report. The amount of water wasted in a month is around 9000m^3 per month if we do the rounding adjustment. Average monthly usage for 1 household in Malaysia is estimated at 20 m^3. So, the amount of water wasted in UTP only can be used to supply in 400 household monthly. This amount of water is continuously being for a period 6 months whereas certain state in Malaysia are facing water crisis, especially in the state of Selangor and Federal Territory (Kuala Lumpur & Putrajaya).As stated in early of this report, the total amount of water being wasted had enabled us to show the energy which is being wasted to supply the wasted treated water. The amount of energy wasted per month is around 1764kWh or 1764 units. The waste amount of energy can be used to power up to 8 households for a period of a month. The average household power consumption in Malaysia is 200 units per household. The energy usage has a direct result on the CO_2 emission which has been calculated and shown in Chapter 4 analysis part.The amount of CO_2 emission caused by this wastage is nearly 500kg per month which is equivalent for 0.5 metric Tons per month. This water wastage has a direct result on cost loss. The extra costing caused by this wastage is RM14000, which accounts to 7% of the total water bill of UTP. In conclusion, This report serves as a prove that the water leakage in UTP is causing a major wastage on monetary and energy, also causing a significant impact to the environment by emitting unwanted carbon dioxide to the environment. The report stands as platform for energy audit of water facilities in Universiti Teknologi PETRONAS. This paper is crucial as it would be a major step forward on energy auditing field as the methods can be implemented in every other places of PETRONAS Management Unit for energy auditing purposes. The methodology which had been used in this paper or research can be used at other sectors for wastage or energy auditing purposes

5.2 RECOMMENDATIONS

I would like to propose few recommendations regarding the issues addressed in this report and also recommend the future study which should be continued with this report. This recommendation involves all the stake holders in UTP. The stake holder which are referred here are the Students, staff, lecturer, maintenance personals, maintenance contractors/ vendors, UTP management board and the treated water supplier (Lembaga Air Perak-LAP). The recommendations are as following.

1) Provide a Routine Maintenance Schedule for all the water outlets in UTP.

The PMMD unit of UTP should provide or prepare a routine or periodical maintenance schedule to carry out maintenance work at the water outlets around UTP. Currently repairs are done on report basis, where awareness of stake holders plays a key role in reporting. The awareness of stake holder is considerably is in low level where repairs mostly goes unreported and unattended.

2) Increase Man-power in PMMD (Property management and maintenance department) is a must do changes.

Man power or number of staff in PMMD of UTP should be increased. Currently the mechanical maintenance such as water facilities management and other mechanical and electrical (M&E) maintenance is carried out by single person. The person in charge is Mr. Noorhazrin B. Basri. The work load for one person to manage everything is tremendously high, which I would like to suggest to UTP to increase the staff in M&E maintenance branch of PMMD unit.

3) A Systematic reporting channel & reporting signage should be introduced.

Proper reporting channel should be introduced such as one stop reporting for all defaults in UTP would be a great advantage. This will provide the stake holders a steady platform to report defaults in UTP. Currently reporting signage are provided at academic block by the PMMD with details of person in charge and reporting emails. This is a good effort by PMMD department and it should be expanded to other facilities in UTP such as residential village, labs, cafeteria and etc.

4) An Allocation of minor budget should be made in order to repair minor faulty in the water outlet.

Allocation of minor budget by UTP management to repairs this leaking water outlets would be a great consideration. Based on my observations which I had stated in Remarks column in table 2 of this report, it can be seen that the defaults are caused by minor repairs at the water outlets. Most of the water outlets are malfunctioned due to faulty rubber washer, or faulty float, faulty pumping mechanism n etc. These repairs are minor and can be tackled easily. Normally a rubber washer will cause around RM0.20, by replacing it, in long term we can save more than RM0.20 and UTP can be labeled as a green campus.

5) Appointment of permanent vendor/contractor for water facility maintenance

Appointment of permanent vendor/contractor for water facility maintenance will enable us to tackle the routine maintenance problem and also minor repairs can be repaired time to time without any problems. This step can save huge amount of money in long term. Engineering economic analysis should be done on the viability of this suggestion. A class F mechanical and electrical (M&E) maintenance contractor/vendor firm can be called in to serve this purpose.

6) Study on Stake holder awareness and also recommendation feasibility.

This report on the experiment should be continued in further to analysis the actual cause of leakage with regards of all the stakeholders involved. The study should continue to show the relationship between the water wastage and stake holders involvement. Feasibility study also should be carried out on certain recommendations stated above using engineering economic analysis. This will show in long term the benefits and loss for UTP. The recommendation of Appointment of permanent vendor/contractor for water facility maintenance should be very much considered to be analyzed in engineering economics aspect.

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