MWH

BUILDING A BETTER WORLD

REPORT

HCM City Water Supply Project Energy Efficiency Audit

Prepared for Sawaco/Asian Development Bank

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REPORT

HCM City Water Supply Project Energy Efficiency Audit

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1 Abbreviations and Acronyms

The following abbreviations and acronyms have been used in this report. The meanings of each of these have been included below for clarity.

ADB	Asian Development Bank
BOD	Biochemical Oxygen Demand or Biological Oxygen Demand
CDD	Cooling Degree Day
COD	Chemical Oxygen Demand
DCC	Distribution Control Centre
DO	Dissolved Oxygen
DOL	Direct On Line
ECM	Energy Conservation Measure
EEI	Energy Efficiency Index
HCMC	Ho Chi Minh City
HVAC	Heating, Ventilation and Air Conditioning
JS	Joint Stock
JSC	Joint Stock Company
KPI	Key Performance Indicator
kW	Kilo-watts
kWh	Kilo-watt hours
m^3	Cubic metres
Mm^3	Million cubic metres
MWH	MWH Consultants (S) Pte Ltd
NPV	Net Present Value
PS	Primary Sedimentation
RW	Raw Water
SAWACO	Saigon Water Company
SCADA	Supervisory Control and Data Acquisition
TW	Treated Water
VFD	Variable Frequency Drive (another name for variable speed drive)
VSD	Variable Speed Drive (another name for variable frequency drive)
WTP	Water Treatment Plant

2 Executive Summary

MWH was requested to undertake energy audits of existing infrastructure belonging to the Ho Chi Minh City water supply system as part of an Asian Development Bank funded development study.

In conjunction with a local energy auditing consultant, MWH has conducted energy audits at locations covering the full range of operations across HCMC's water supply system. This report provides a summary of the findings and recommendations arising from this effort.

The following sites were included in the audit.

- Thu Duc WTP – Raw Water Pumping
- Thu Duc WTP – Treated Water Pumping
- Thu Duc WTP – Backwash System
- Thu Duc WTP – Office, Workshop, Ancillaries
- Tan Hiep WTP – Raw Water Pumping
- Tan Hiep WTP – Treated Water Pumping
- Tan Hiep WTP – Backwash System
- Tan Hiep WTP – Office, Workshop, Ancillaries
- Thu Duc BOO WTP
- Binh An WTP
- Trung An Water Supply Company
- Hoc Mon WTP
- SAWACO Headquarters Offices
- JS Company Office Zone 3
- JS Company Office Zone 5

At each location the key energy using items were noted and energy saving measures were identified and costed.

The measures have been sorted into four groups: no cost, payback period up to 3 years, 3 to 5 years and greater than 5 years.

The capital costs for these groups are as follows.

Payback Period	x1000US$	x1000VNDong
No Cost	0	0
Short Term 0 to 3 years	1,500	26,000,000
Medium Term 3 to 5 years	750	13,000,000
Longer Term greater than 5 years.	2,900	51,000,000

The most significant short term payback measure is the installation of VSDs for the treated water pumps at Thu Duc. This has an estimated cost of US1,300,000 (23,760,000,000VND) and a payback period of 2.8 years.

Another significant item because of the short payback period is the modification of the filter backwash process at the Hoc Mon WTP. This has an estimated cost of US$16,000 (286,000,000VND) and a payback period of 0.36 years.

Other short term pay back measures include installation of VSDs on pumps, of higher efficiency florescent lamps, of extra transformers, of more efficient pumps, of capacitor banks, and of more efficient air conditioners.

Many of the medium and longer term payback measures are the same as the short term ones mentioned above.

3 Introduction

MWH was requested to undertake energy audits of existing infrastructure belonging to the Ho Chi Minh City water supply system as part of an Asian Development Bank funded development study. This work forms a part of a program of institutional strengthening and sits alongside other work aimed at improving the effectiveness of the distribution system so as to meet the needs of HCMC's residents and businesses.

In conjunction with a local energy auditing consultant, MWH has conducted energy audits at locations covering the full range of operations across HCMC's water supply system. Particular interest has been focussed on the major energy users while also providing sufficient analysis on supporting functions to give a reasonable assessment of the overall performance of the system in relation to energy usage.

This report provides a summary of the findings and recommendations arising from this effort. For detailed assessments and information, ECC's energy audit report is appended.

In order to provide a useful and workable document, the report has been separated into sections dealing with each site and its function, history, operating costs and ECMs with general sections preceding and introducing the audit process and summarising the entire program.

The following sections indicate the structure of the report.

Section 1	Abbreviations and Acronyms
Section 2	Executive Summary
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Section 5	Thu Duc WTP
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Section 8	Binh An WTP
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Section 14	Consolidated Summary and Recommendations

We sincerely thank the SAWACO personnel for their gracious assistance during the course of the energy audits and compilation of this report.

Calculations and conversions completed in this report have utilised the following rates:

1 kWh = 0.43kgCO_2
1 USD = 17,805 VNĐ

4 Energy Audit Locations

4.1 Selection of Sites

In order to identify the major energy savings opportunities within the various locations available to audit, a primary concern was to capture the major energy consumers within the HCMC water production and supply system. With assistance from SAWACO personnel MWH was able to identify the key locations for audits to be undertaken, and was further able to supplement these sites with a number of less critical sites (such as the JSC offices) in order to provide a more in depth and broader understanding of the energy usage situation relating to the system.

The following sites and energy users were chosen and audited:

Table 4-1 : Energy Audit Locations and Report References

Audit Location	Report Section	Report Page
Thu Duc WTP – Raw Water Pumping	Section 5	Page 5
Thu Duc WTP – Treated Water Pumping	Section 5	Page 5
Thu Duc WTP – Backwash System	Section 5	Page 5
Thu Duc WTP – Office, Workshop, Ancillaries	Section 5	Page 5
Tan Hiep WTP – Raw Water Pumping	Section 6	Page 12
Tan Hiep WTP – Treated Water Pumping	Section 6	Page 12
Tan Hiep WTP – Backwash System	Section 6	Page 12
Tan Hiep WTP – Office, Workshop, Ancillaries	Section 6	Page 12
Thu Duc BOO WTP	Section 7	Page 17
Binh An WTP	Section 8	Page 20
Trung An Water Supply Company	Section 9	Page 23
Hoc Mon WTP	Section 10	Page 28
SAWACO Headquarters Offices	Section 11	Page 31
JS Company Office Zone 3	Section 12	Page 35
JS Company Office Zone 5	Section 13	Page 37

5 Thu Duc WTP

5.1 Plant Description

The Thu Duc Water Treatment Plant supplies the majority of Ho Chi Minh's treated water supply. First commissioned in 1966, this plant has been progressively modified over the years with its capacity being gradually increased from an initial 450,000m^3/day to now delivering approximately 650,000m^3 of treated water into the HCMC water supply system daily. Taking water from the Dong Nai River, raw water pumps deliver water to the WTP approximately 10 km away. Here the water is treated in a traditional manner using the following processes:

- Flocculation (following dosing with alum to aid flocculation)
- Primary Sedimentation
- Sand Filtration
- Storage

From here, treated water is pumped into the primary water pipeline to HCMC.

5.2 Plant Operation

5.2.1 Hoa An Raw Water Pumping Station

- The Pumping Station has seven transformers:
  - Three 5000kVA(15kV/4.16kV) transformers (duty/duty/standby): These supply electricity to the whole pumping station. The raw water pumps are the major energy users (medium voltage 4.16kV).
  - Two 150kVA(4.16kV/440V) transformers branching from the two main 5000kVA transformers. They supply three-phase motors (low voltage 440V).
  - Two 75kVA(440V/208V/127V) transformers branching from the two 150kVA transformers to supply the electric lighting system, for controls and for other equipment.
- This pumping station has six raw water pumps with synchronous motors:
  - Brand: WEIR
  - Power: 1680kW / 2250HP
  - Pressure: 75.6m H_2O
  - Flow: 6246 m^3/hour
  - Five pumps are duty and one backup/off-peak pump for use when water levels in the treated water basin are low.

5.2.2 Thu Duc Water Treatment Plant – Energy Supply

- The Treatment Plant has seven transformers:
  - Two 5000kVA(15kV/4.16kV) transformers supplying the whole plant. The treated water pumps are the major energy users (medium voltage 4.16kV).
  - Two 1000kVA(4.16kV/440V) transformers branching from the two main 5000kVA transformers. They supply three-phase motors (low voltage 440V).
  - Two 75kVA(440V/208V/127V) transformers and one 112.5kVA(440V/208/120V) transformer. These supply electricity for the lighting system, controls and other equipment.

5.2.3 Thu Duc Water Treatment Plant – Sand Filtration

- 20 filtration basins arranged in parallel are used at Thu Duc.
- Filters are typically backwashed once every two days.
- Backwashing takes approximately 30 minutes.

5.2.4 Thu Duc Water Treatment Plant – Treated Water Pumps

- The WTP has five treated water pumps operating at between 11,280 m^3/h and 12,000m^3/h with efficiencies between 86% and 88%. Motors are: three at 1,125kW and two at 1,500kW. All motors are synchronous.
- Flow of treated water is manually controlled by a throttling valve and is wasting energy.
- In addition to the output of the Thu Duc WTP (650,000m^3/day), the treated water pumps deliver water produced by the Binh An WTP (100,000m^3/day) and the Thu Duc BOO WTP (100,000m^3/day at present). Therefore, in reviewing the KPIs/EEIs for pumping, allowance has been made for this.

5.2.5 Ancillary Items: Hoa An Cooling Pumps:

- This system has three cooling water pumps. Each has an 11kW electric motor.
  - Two Torishima pumps delivering 25 m^3/h each.
  - One KSB pump delivering 24 m^3/h.
- This plant operates one pump 24 hours per day. The other pumps only operate two times per week for about 30 minutes to serve treatment water processes. The control conditions for this system are not optimal. Flow from the cooling water pump is always constant while the cooling demand from the raw water pumps changes according to the number of pumps in operation (five or six raw water pumps).

5.2.6 Ancillary Items: Thu Duc Cooling Pumps:

- The Thu Duc plant operates four cooling pumps (two 11kW pumps and two 3kW pumps). Two duty pumps, one 11kW pump and one 3kW pump, and the other pumps are backups.
- Throughout the week, the chiller operates at varying loads. The cooling pump which pumps water to the chiller, however, always operates at 100% load and does not change speed to meet demand. This method of pump control is wasteful.
- The cooling tower pump (15kW) is similar to cooling water pump.

5.3 Baseline Energy Efficiency Index

The energy efficiency index (EEI) for Hoa An in 2007 and 2008 averages 0.171 (kWh/m^3) and fluctuates with demand. The monthly variations for the EEI range from -7.1% up to 5.8% of the average index. This small variation shows there are no inherent problems with the system.

The EEI for the Thu Duc WTP in 2008 averages at 0.17 (kWh/m^3) with small monthly fluctuations between -2.2% and 1.6% of the average index. Similarly, the small fluctuations show no inherent problems with the Thu Duc WTP.

5.4 Review of Charging Structures

5.4.1 Charging Structures

Electricity for both the Hoa An pumping station and the Thu Duc WTP is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,830 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 510 (VNĐ/kWh)
- Normal rate All other times 920 (VNĐ/kWh)

5.4.2 Time of Use Analysis

The treatment process at Thu Duc WTP is relatively constant year round, with little daily, weekly, monthly or annual variation. The storage associated with the process, and that available within the HCMC water system is not sufficient to enable scheduling of water treatment to take full advantage of the variable electricity prices.

If significant additional storage was provided (either at Thu Duc or elsewhere in HCMC) for the treatment process, and modifications made to the process itself, production could be scheduled to produce more water overnight, at a lower electricity rate, thus reducing the cost of production. The extent of this measure and its viability is an extensive exercise and a study in itself and is beyond the current scope of this energy audit. However, when combined with considerations relating to the hydraulics of the system, where storage is also expected to be a recommendation, this looks to be a viable option to consider in further detail as the project advances.

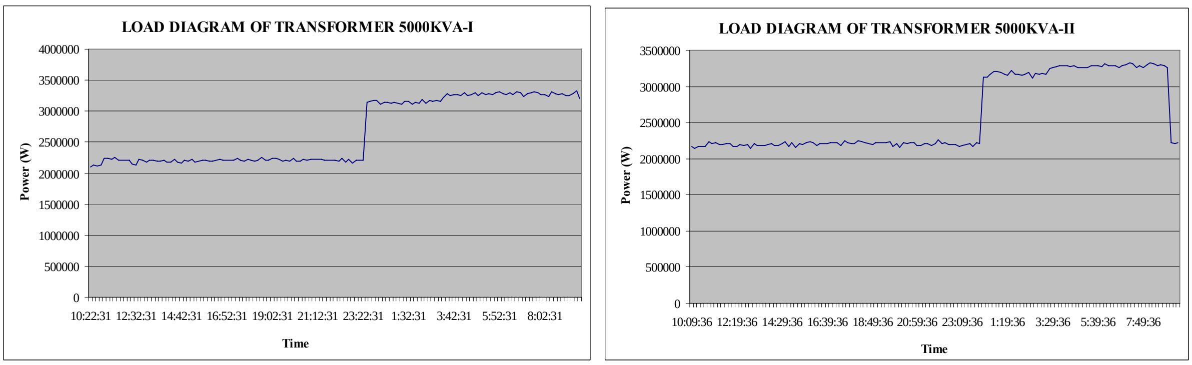
The opportunity does exist to schedule some operations away from the peak charging periods and therefore to reduce expenditure. This is discussed in the Energy Conservation Measures section following.

5.5 Energy Usage Monitoring

5.5.1 Hoa An Raw Water Pumping Station

Energy usage was measured and monitored in a number of locations, but two of the more interesting results are shown in the following figure.

Figure 5-1 : Energy Monitoring Results: Hoa An Transformers

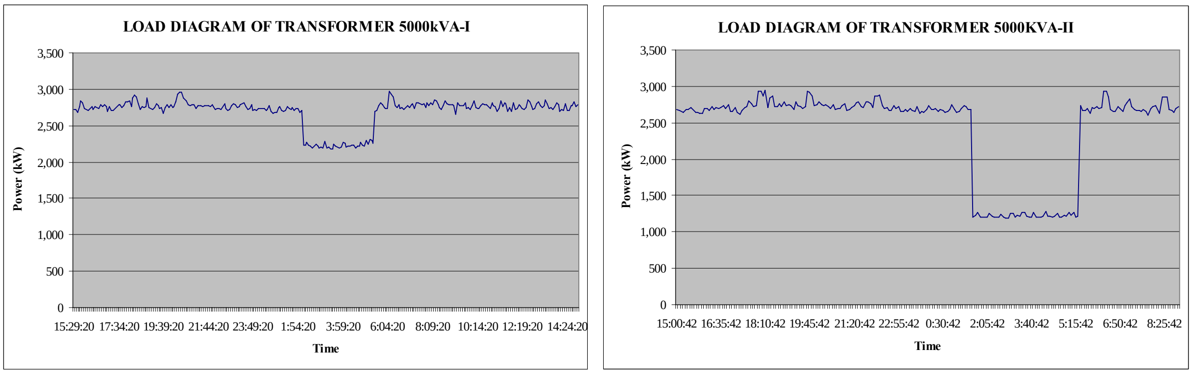


These show the very steady energy usage associated with the raw water pumps and the use of extra pumps during periods of low electrical cost. Here three pumps are shown to be running during the majority of the day, with a further pump being energised through the night.

5.5.2 Thu Duc Water Treatment Plant

Energy usage was measured and monitored in a number of locations, but two of the more interesting results are shown in the following figure.

Figure 5-2 : Energy Monitoring Results: Thu Duc Transformers



The significant base load provided by the treated water pumps is evident in the above monitoring results. The significant reduction in load seen in the graphs relates to the isolation of one of the 1,500kW treated water pumps.

5.6 Energy Conservation Measures

In the following sections, energy conservation measures are briefly described. Each measure is uniquely identified with an item number. These numbers include a site identifier. In this case this identifier is HA for Hoa An and TD for Thu Duc.

5.6.1 ECM-HA-01: Lighting System: Fluorescent Lamp Replacement

This pumping station uses 254 1.2m and 42 0.6m T10 fluorescent lamps with electromagnetic ballasts within the equipment rooms and offices. Replacement of the lamps and ballasts with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

5.6.2 ECM-HA-02: Lighting System: Mercury Lamp Replacement

The Hoa An pumping station uses 58 mercury high pressure lamps 250W for public lighting. Operation time is 12 hours/day. The replacement of the mercury high pressure lamps 250W to natri high pressure lamps 100W will result in energy savings with minimal impact on lighting performance.

5.6.3 ECM-HA-03: Air Conditioner: Repair and Maintain

The raw water pump room uses one Trane air conditioner with 240,000Btu/h / 70kW of cooling capacity at a COP = 1.08. The distributor of this air conditioner has indicated that this machine is low on refrigerant and the condition of the air conditioner is poor. Repairing and re-gassing the air conditioner will markedly improve the COP to about 2.5 and improved maintenance will keep this unit running efficiently.

5.6.4 ECM-HA-04: Raw Water Pumps: Install VSDs

Energy monitoring and analysis of the pump operation and efficiency indicates that these pumps are running well and do not require any adjustments. The installation of VSDs could provide a small reduction in energy usage but this is insufficient to justify the investment.

5.6.5 ECM-HA-05: Air Compressor: Automate Controls

This pumping station operates two air compressors in a duty / standby arrangement. The capacity of each air compressor is 5HP / 3.73kW. The operating pressure is 6.2-8.3 bars and the pressure demand of the technology department is 4.8-6.2bar. There is scope to reduce the compressed air system pressure and therefore reduce energy consumption. However, the technology department has indicated that they wish to maintain the existing pressure setpoints to provide a safety margin in the system. This measure has therefore not been explored further.

Raw water is used to cool the air compressors. This water runs continuously for cooling and becomes wastewater once it is passed through the cooling loop even though the compressor may have stopped working. Based on load diagram 17% of time the air compressor is at full load and 83% of time there is no load. Installing an automatic control system to turn the cooling system on/off at the same time the air compressor turns on/off will reduce the amount of water wasted and reduce the energy consumed by the cooling water pumps.

5.6.6 ECM-TD-01: Filtration Basin Wash: Load Shifting

The Thu Duc WTP has 20 filtration basins and they have to wash at least ten basins every day. This means, during four hours of peak time they wash two basins. To wash these basins they operate the centrifugal blower and backwash pump. For each basin, the average operation time for a wash is 30 minutes. By scheduling the backwash to avoid the peak electrical periods, a significant operational cost saving can be made.

5.6.7 ECM-TD-02: Lighting System: Fluorescent Lamp Replacement

This plant uses 580 1.2m and 250 0.6m T10 fluorescent lamps with electromagnetic ballasts. Replacement of the T10 fluorescent lamps and electromagnetic ballast by T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

5.6.8 ECM-TD-03: Water Chiller: Replacement

This plant has two chiller systems (one is duty and one is backup), capacity norm of the compressor is 75kW per chiller. The COP of both chillers has been measured as approximately 2.6. This is low when compared with a new chiller with a COP of 4. Replacement of the chiller with the more efficient system will save money through a reduction in energy.

5.6.9 ECM-TD-04: Cooling Water Pump & Cooling Tower Pump: Install VSDs

a) Installing VSDs for the cooling water pumps will allow their speed to match the demand of the chiller, reducing the energy consumption of the pumps and saving money.

b) The Cooling tower pump (15kW) is similar to cooling water pumps in terms of capacity. If the chiller is replaced (as in ECM-TD-03), the flow through the cooling tower will reduce. Installing a VSD on the cooling tower pump will allow it to match the demand on the tower and save energy.

5.6.10 ECM-TD-05: Treated Water Pumps: Install VSDs

The installation of VSDs will save money by only pumping at the required pressure to deliver the required flow.

5.6.11 Summary

Table 5-1 : Energy Conservation Measures for Hoa An Raw Water Pumping Station

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Electricity Saving (kWh/year)	Saving Cost (x1000VND/ year)	Payback Time (year)	C02 reducing (kg/year)
HA-01a	Replace fluorescent lamp 1.2m T10 to fluorescent lamp T5	2.595	46,206	16,688	16,805	2.75	1,176

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Electricity Saving (kWh/year)	Saving Cost (x1000VND/ year)	Payback Time (year)	C02 reducing (kg/year)
HA-01b	Replace fluorescent lamp 0.6m T10 to fluorescent lamp T5	0.273	4,862	1,073	1,081	4.50	461
HA-02	Replace mercury high pressure lamp 250W to natri high pressure lamp 100W	1.349	24,012	34,041	34,279	0.70	14,638
HA-03	Repair air conditioner 240,000BTU/h	0.842	15,000	113,291	114,084	0.13	48,715
HA-04	Install VSDs for the raw water pumps	1.526	27,170	2,744	2,763	9.83	1,180
HA-05	Automate the cooling system's air compressors	0.449	8,000	2,628	2,646	3.02	1,130
Total		**7.034**	**125,250**	**170,465**	**171,658**	**0.73**	**67,300**

Table 5-2 : Energy Conservation Measures for Thu Duc Water Treatment Plant

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
TD-01	Load shifting for washing filtration basin	0	0	0	38,292	0.00	0
TD-02a	Replace fluorescent lamp T10 to fluorescent lamp T5	5.926	105,509	60,970	61,397	1.72	25,180
TD-02b	Replace fluorescent lamp 0.6 m - T10 to fluorescent lamp 0.6 m - T5	1.625	28,941	10,220	10,292	2.81	4,221
TD-03	Replace the existing chiller water system to the new one which efficiency is higher	31.261	556,600	129,545	130,452	4.27	53,502
TD-04a	Install VSD for cooling water pump	1.526	27,170	22,469	22,626	1.20	9,280
TD-04b	Install VSD for cooling tower water pump	1.928	34,320	29,460	29,666	1.16	12,167
TD-05[1]	Install VSD for treated water pump	1,334.457	23,760,000	9,951,579	8,558	2.8	4,279,179
Total		**1,376.723**	**24,512,540**	**10,204,243**	**301,283**	**2.8**	**4,383,529**

5.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table identifies these opportunities.

Table 5-3 : Recommended ECMs for Thu Duc Water Treatment Plant

[1] Note that this calculation differs from that presented in the appended report.

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
HA-01a	Replace fluorescent lamp 1.2m T10 to fluorescent lamp T5	2.595	46,206	2.75
HA-02	Replace mercury high pressure lamp 250W to natri high pressure lamp 100W	1.349	24,012	0.70
HA-03	Repair air conditioner 240,000BTU/h	0.842	15,000	0.13
TD-01	Load shifting for washing filtration basin	0	0	0.00
TD-02a	Replace fluorescent lamp T10 to fluorescent lamp T5	5.926	105,509	1.72
TD-02b	Replace fluorescent lamp 0.6 m - T10 to fluorescent lamp 0.6 m - T5	1.625	28,941	2.81
TD-04a	Install VSD for cooling water pump	1.526	27,170	1.20
TD-04b	Install VSD for cooling tower water pump	1.928	34,320	1.16
TD-05	Install VSD for treated water pump	1,334.457	23,760,000	2.8
Total		**1,350.248**	**24,041,158**	

The table above incorporates one measure that carries additional importance in relation to NRW reduction. This measure, TD-05, has a payback of 2.8 years. The NRW implications have not been fully included in the review here as they are dependent on system upgrades and operational changes that are beyond the direct control of the plant. However, ensuring that the treated water pumps are able to efficiently respond to system demand and to improvements in NRW management is a key aspect of this project, and therefore this recommendation is highlighted as crucial.

6 Tan Hiep WTP

6.1 Plant Description

The Tan Hiep Water Treatment Plant supplies between 285,000m^3/day and 300,000m^3/day into Ho Chi Minh's treated water supply. Taking water from the Sai Gon River, raw water pumps at Hoa Phu deliver water to the Tan Hiep WTP. Here the water is treated in a traditional manner using the following processes:

- Flocculation (following dosing with alum to aid flocculation)
- Primary Sedimentation
- Sand Filtration
- Storage

From here, treated water is pumped into the primary water pipeline to HCMC.

6.2 Plant Operation

6.2.1 Hoa Phu Raw Water Pumping Station

- The pumping station uses a 15 kV feed from the national grid. It has four transformers:
    - Two 2,500kVA (15kV/6kV) transformers: These supply the raw water pumping station. This system has an automatic capacitor bank. Operation is duty/standby
    - Two 400kVA (15kV/400V) transformers: These supply electricity for areas with low voltage equipment like the chemical area, water treatment area and for general lighting. This system has an automatic capacitor bank. Operation is duty/standby.
- This pumping station has three raw water pumps (duty/duty/standby):
    - Brand: Weir
    - Power: 973kW
    - Pressure: 39.97m H_2O
    - Flow: 6,840 m^3/hour
- Water flow is controlled by a throttling valve. This is an energy inefficient control method.

6.2.2 Tan Hiep Water Treatment Plant – Energy Supply

The plant uses a 15 kV feed from the national grid. It has four transformers:

- Two transformers 4000kVA (15kV/6kV): These supply electricity for the treated water pumping station. This system has an installed automatic capacitor bank with a total capacity of 1050kVAR and the power factor is good (0.929-0.934) with low losses. One transformer operates as duty and the other as a backup.
- Two transformers 800kVA (15kV/400V): These supply electricity for areas with low voltage equipment like the chemical area, for filtration basin washing and for general lighting. This system has an installed automatic capacitor bank with a total capacity of 200kVAR.

6.2.3 Tan Hiep Water Treatment Plant – Treated Water Pumps

- The WTP has three treated water pumps with 1,411 kW capacity. These pumps operate at 5,800 m^3/h – 6,400m^3/h with an efficiency between 86.5% - 87.5%. Operation is duty / duty / standby.
- Treated water flow is manually controlled by a throttling valve and so this system is inefficient.

6.2.4 Ancillary Items: Tan Hiep Backwash Pumps

- The backwash pump is rated at 85kW, but has a measured demand of 60.6kW
- From the energy audit, the throttling valve on the first backwash pump was noted to be open at 70% and the valve on the second backwash pump was open at 50%. This setup gives 1bar of pressure for washing the basins.

6.3 Baseline Energy Efficiency Index

EEI for Hoa Phu raw water pump station in 2008 averages at 0.159 (kWh/m^3) and varies with demand. Monthly variations range from -4.1% up to 2.8% of the average index. The monthly variations are small and acceptable.

EEI for Tan Hiep WTP in 2008 averages 0.404 (kWh/m^3) with monthly fluctuations between -2.6% and 1.9% of the average index. Similarly, the small fluctuations show no inherent problems with the Tan Hiep WTP.

6.4 Review of Charging Structures

6.4.1 Charging Structures

Electricity for both Hoa Phu and Tan Hiep WTP is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,830 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 510 (VNĐ/kWh)
- Normal rate All other times 920 (VNĐ/kWh)

6.4.2 Time of Use Analysis

The treatment process at Tan Hiep WTP is relatively constant year round, with little daily, weekly, monthly or annual variation. The storage associated with the process, and that available within the HCMC water system is not sufficient to enable scheduling of water treatment to take full advantage of the variable electricity prices.

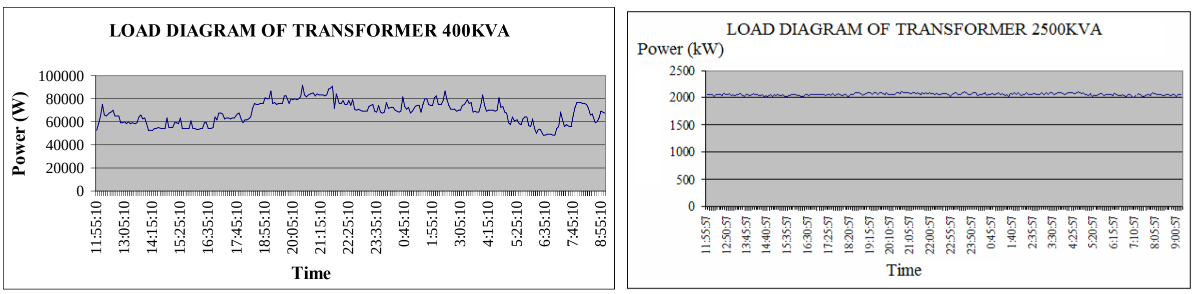
The opportunity does exist to schedule some operations away from the peak charging periods and therefore to reduce expenditure: this applies to filter backwashing in particular.

6.5 Energy Usage Monitoring

6.5.1 Hoa Phu

Energy usage was measured and monitored in a number of locations, but two of the more interesting results are shown in the following figure.

Figure 6-1 : Energy Monitoring Results: Hoa Phu Transformers

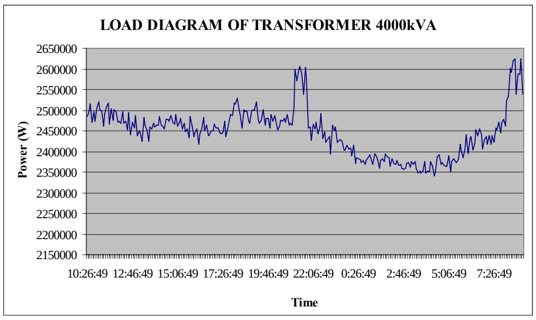


The load on the 400kVA transformer shows that it is process driven with some possible night lighting loads resulting on a higher night-time peak. The continuous operation of the raw water pumps is obvious on the second graph.

6.5.2 Tan Hiep

Energy usage was measured and monitored in a number of locations, and the results from one of the transformers are shown in the following figure.

Figure 6-2 : Energy Monitoring Results: Tan Hiep Transformer



The scale on the y axis of the graph is slightly misleading as the variations in power demand are much smaller than they appear. This generally shows a very stable load with short peaks (possibly associated with the backwash process).

6.6 Energy Conservation Measures

In the following sections, energy conservation measures are briefly described. Each measure is uniquely identified with an item number. These numbers include a site identifier. In this case this identifier is HP for Hoa Phu and TH for Tan Hiep.

6.6.1 ECM-HP-01: Lighting System: Fluorescent Lamp Replacement

This station uses 60 fluorescent lamps T10 and electromagnetic ballast. Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

6.6.2 ECM-HP-02: Raw Water Pumps: Install VSDs

Install two VSDs for three raw water pumps and control the pumps to maintain pressure inside the pipe to the Tan Hiep WTP. The pumps will operate to the same pressure and flow as at present (39.97mH_2O at 6,840 m^3/h flow). This results in a 6% reduction in motor speed (to 47Hz).

6.6.3 ECM-HP-03: Install 2500kVA Transformer

There are currently two transformers with 2500kVA capacity. One transformer operates as the duty while the other one is a backup. The load factor of the operating transformer is 86-89%. At this load factor, the energy loss in the winding is 19.6 kW. Installing one new 2,500KVA transformer will allow two transformers to operate at the same time with each transformer to supply one raw water pump. With this solution the load factor of each transformer will be between 46 – 52%. The expected reduction in energy is 5.3kW from 19.6 kW to 14.3kW.

6.6.4 ECM-HP-04: Lime Solution Pumps: Install VSD

Lime is added to the raw water to adjust the pH level to about pH 7 before pumping to Tan Hiep WTP using a fixed speed 2kW pump. When the river quality changes the flow of lime is adjusted manually by means of a throttling valve. The installation of a VSD for the lime solution pump will save on power and also remove the need for manual adjustment of the throttling valve.

6.6.5 ECM-TH-01: Lighting System: Fluorescent Lamp Replacement

This plant uses about 500 of fluorescent lamps T10 and electromagnetic ballast. Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

6.6.6 ECM-TH-02: Treated Water Pumps: Install VSDs

Installing VSDs for the treated water pumps will result in a reduction in pump speed and power when operating at 49.5mH_2O and a flow of 6,167 m^3/h. Two VSDs will be installed for three pumps to be able to adjust the motor load to suit flow demand and keep the pressure stable.

6.6.7 ECM-TH-03: Backwash Pumps: Install VSD

The filtration basins are washed using a number of different steps. The water-wash step is particularly inefficient with a throttling valve being used to adjust the water pressure to around 1 bar. Installing a VSD on one backwash pump will allow the other pump to be run at full capacity while the second will run at 50% to deliver 1 bar of pressure. This operating regime will save power when compared to running both pumps at full capacity.

6.6.8 Summary

Table 6-1 : Energy Conservation Measures For Hoa Phu

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
HP-01	Replace fluorescent lamp T10 to fluorescent lamp T5	0.556	9,900	7,096	7,146	1.38	3,000
HP-02	Install VSD for raw water pump 973 kW	1,297	23,100,000	3,993,000	3,825,000	6.0	1,717,000
HP-03	Install one 2500KVA transformer	44.931	800,000	46,496	46,822	17.1	20,000
HP-04	Install VSD for lime solution pump	0.364	6,480	5,606	5,646	1.15	2,000
Total		**1,342.851**	**23,916,380**	**4,052,198**	**3,884,614**	**6.15**	**1,742,000**

Table 6-2 : Energy Conservation Measures For Tan Hiep

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
TH-01	Replace fluorescent lamp T10 to fluorescent lamp T5	5.108	90,956	17,280	17,401	5.23	7,430
TH-02	Install VSD for treated water pump	1427.127	25,410,000	4,253,520	4,283,295	5.93	1,829,013

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
TH-03	Install VSD for backwash pump	6.345	112,970	3,807	3,834	29.47	1,637
Total		**1438.58**	**25,613,926**	**4,274,607**	**4,304,530**	**5.95**	**1,838,080**

6.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table identifies these opportunities.

Table 6-3 : Recommended ECMs for Tan Hiep Water Treatment Plant

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
HP-01	Replace fluorescent lamp T10 to fluorescent lamp T5	0.556	9,900	1.38
HP-04	Install VSD for lime solution pump	0.364	6,480	1.15
TH-02	Install VSD for treated water pump	1427.127	25,410,000	5.93
Total		**1428.047**	**25,426,380**	

The table above also incorporates one measure that lies outside the criteria defined above. This measure, TH-02, has a payback of 5.93 years but has significant implications in relation to NRW reduction. These implications have not been fully included in the review here as they are dependent on system upgrades and operational changes that are beyond the direct control of the plant. However, ensuring that the treated water pumps are able to efficiently respond to system demand and to improvements in NRW management is a key aspect of this project, and therefore the recommendation is to include this measure in a funding application.

7 Thu Duc BOO WTP

7.1 Plant Description

The Thu Duc BOO Water Treatment Plant is neither owned nor operated by SAWACO but it is designed to deliver approximately 300,000m^3/day of treated water to HCMC. The plant consists of:

- Hoa An Raw Water Intake Pumping Station (315,000m^3/day)
- Thu Duc BOO WTP (300,000m^3/day)
- Treated water reservoir (43,500m^3)
- Treated water pumping station (420,000m^3/day)
- An administration office
- A treated water DN900-DN2000 pipeline of 26km long

The WTP incorporates the following treatment methods:

- Flocculation,
- Sedimentation,
- Filtration with underdrains,
- Automatic sludge collection and suction,
- On-demand automatic regulation of treated water pumping

7.2 Plant Operation

The current operation of the plant (phase 1) supplies a treated water quantity of 100,000m^3/day. This will increase to the design capacity (300,000m^3/day) by the end of the year.

7.2.1 Hoa An BOO Raw Water Pumping Station

- Two 4000KVA transformers run from national grid at 22KV supply electricity for four raw water pumps 900kW (medium voltage). The efficiency for the 4000KVA transformers is 99.07% and the power factor is 0.97.
- This plant has four installed raw water pumps. In this phase, this plant operates one raw water pump with below operation data:
  - Capacity: 815 kW.
  - Flow: 4,392 m^3/hour
  - Pressure: 55m H_2O.
  - Efficiency: 85%.
- Flow control is achieved by manual adjustment of a throttling valve.

7.2.2 Thu Duc BOO WTP

- The Thu Duc BOO WTP uses two 6000KVA transformers run from the national grid at 22KV to supply electricity for four 1250kW treated water pumps (medium voltage).
- Two 750KVA transformers supply electricity for the other equipment in the WTP. The power factor for these four transformers is 0.98.

7.3 Baseline Energy Efficiency Index

The data collected during the audit period indicated that the EEI for raw water is 0.21KWh/m^3.

The average EEI of treated water in is 0.173 KWh/m^3 with daily fluctuations between -3.7% and 4.4% of the average index. The EEI is quite stable. However, we can not exactly assess the EEI because this plant only has one power meter for whole plant (including the plant and office).This plant should install power meters for each zone in the plant, in particular, one power meter for treated water pumping station.

7.4 Review of Charging Structures

7.4.1 Charging Structures

Electricity for the Thu Duc BOO WTP is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,830 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 510 (VNĐ/kWh)
- Normal rate All other times 920 (VNĐ/kWh)

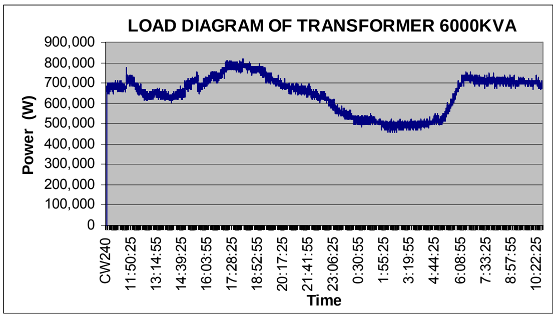
7.4.2 Time of Use Analysis

Scheduling processes such as sand filter back washing to avoid peak times could be investigated here, but the remainder of the plant operation needs to operate on a continuous basis.

7.5 Energy Usage Monitoring

Energy usage was measured and monitored in a number of locations, but one of the more interesting results is shown in the following figure.

Figure 7-1 : Energy Monitoring Results: Thu Duc BOO Transformer



The major load on this transformer is the supply to the treated water pumps. The significant variation shown in the preceding figure indicates that the power drawn by these pumps varies throughout the day: confirmation of the automatic regulation employed at this plant. This is an efficient method of control. Further investigations into scheduling the pumps to run during low tariff periods may be warranted however, as it appears that the treated water pumps are drawing most power during the peak tariff periods.

7.6 Energy Conservation Measures

In the following sections, energy conservation measures are briefly described. Each measure is uniquely identified with an item number. These numbers include a site identifier. In this case this identifier is BO for the Thu Duc BOO WTP.

7.6.1 ECM-BO-01: Raw Water Pump: Install VSD

Install VSD for raw water pump to adjust flow of raw water instead of utilising a throttling valve. With 3,900m^3/hour of flow, this pump will operate at below data after installing VSD.

- Power: 571kW
- Pressure: 43.4m H_2O
- Speed: 657 rpm

7.6.2 ECM-BO-02: Window Treatments: Apply Insulating Film

This plant uses 11 air conditioners to keep the equipment rooms at appropriate environmental conditions. These rooms receive a significant amount of solar gain which can be reduced by applying insulation film on the windows.

7.6.3 Summary

Table 7-1 : Energy Conservation Measures For Thu Duc BOO

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
BO-01	Install VSD for raw water pump	393.148	7,000,000	2,128,680	2,143,581	3.3	9,153,324
BO-02	Use insulation film for windows	3.370	60,000	42,928	43,239	1.4	18,450
Total		**396.518**	**7,060,000**	**2,171,608**	**2,186,820**	**3.23**	**9,171,774**

7.7 Recommendations

As should be expected of a relatively new plant, few measures have been identified for implementation. It is expected that the operation of the plant will develop over time and that further ECMs will present themselves as a result of experience gained during the operation of the plant.

8 Binh An WTP

8.1 Plant Description

The Binh An BOT Water Treatment Plant was brought into operation in August 1999 with a treatment capacity of 100,000m^3/day.

8.2 Plant Operation

- The WTP and pump station are supplied from the national grid at 22kV through two transformers.
  - One transformer is 800 kVA and is used to supply electricity for the raw water pumps.
  - A second 1250 kVA transformer is used to supply the treated water pumps. Both transformers have capacitor banks installed and their power factors are less than 0.9.
- The Binh An pump station has six 280kW NIFHUIS POMPEN treated water pumps. These pumps operate at 46mH_2O of pressure and 1,500 m^3/h. Based on the pump curves their efficiency is 90%.
- To supply 100,000m^3 of treated water per day, the station operates four pumps during low price hours (about 45% of total production); two pumps during peak rate hours (about 22% of total production) and three pumps during normal hours. When the demand increases, the station will bring online one more pump in peak time, but the production will not be above 120,000 m^3/day.
- This station uses a pump control valve to maintain the pumped water pressure at 4.6 bar.

8.3 Baseline Energy Efficiency Index

The EEI for the Binh An WTP and pumping station in 2007 averages 0.271 (kWh/m^3) with small monthly fluctuations between -3.2% and 3.1% of the average index. The EEI for 2008 is 0.273 (kWh/m^3) with similar monthly variations of between -5.4% and 3.0%. These variations are small for both years and indicate that there are no inherent problems with the plant.

8.4 Review of Charging Structures

8.4.1 Charging Structures

Electricity for the Binh An WTP and pumping station is priced on the basis of three usage periods:

• Peak rate	(09:30 to 11:30) and (18:30 to 22:30)	1,845	(VNĐ/kWh)
• Low rate	(22:30 to 06:00)	500	(VNĐ/kWh)
• Normal rate	All other times	915	(VNĐ/kWh)

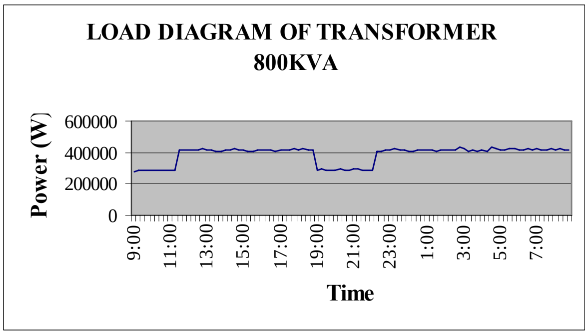
8.4.2 Time of Use Analysis

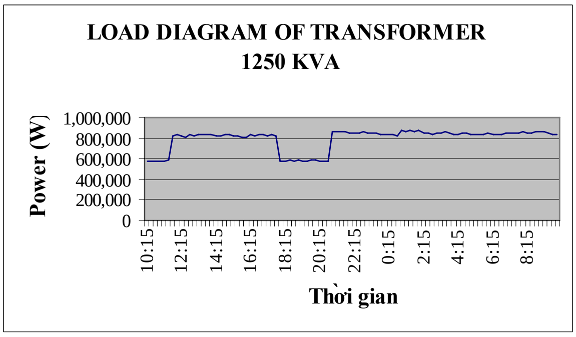
The WTP already schedules treated water pump operation to take advantage of the variable electricity rates.

8.5 Energy Usage Monitoring

Energy usage was measured and monitored in a number of locations, but two of the more interesting results are shown in the following figure.

Figure 8-1 : Energy Monitoring Results: Binh An Transformers





The load monitoring indicates that the plant has identified time of use savings and reduces the power draw during the peak tariff periods. Otherwise the load is shown to be very constant, which is in keeping with the control method determined.

8.6 Energy Conservation Measures

In the following sections, energy conservation measures are briefly described. Each measure is uniquely identified with an item number. These numbers include a site identifier. In this case this identifier is BA for the Bin Anh WTP.

8.6.1 ECM-BA-01: Lighting System: Fluorescent Lamp Replacement

This WTP and pump station uses 50 high pressure 250W lamps and 75 high pressure 400W lamps for public lighting. Replacement of the high pressure 250/400W lamps with compact 55/105W lamps will save energy with a minimal impact on lighting performance.

8.6.2 ECM-BA-02: Treated Water Pumps: Install VSDs

This station uses a pump control valve to maintain pressure from the pump at 4.6 bar and control the flow of water. Energy savings can be realised by replacing the pump control valve with VSDs for the pumps.

This measure involves installing three VSDs for six treated water pumps (one VSD for every two pumps because the plant only operates two or three pumps at any one time) to control the pressure instead of utilizing the pump control valve.

8.6.3 ECM-BA-03: Filtration Basins: VSDs on Pump

This pump station has eight filtration basins which are washed after 72 hours in operation. There are three 45kW backwash pumps and two are used for normal operation. A 90kW centrifugal blower is also used as part of the washing process. During the washing process, the backwash pump is controlled by a throttling valve to adjust flow and pressure. Installing two VSDs for two backwash pumps will save energy by better matching the water demand and reducing over pumping.

8.6.4 Summary

Table 8-1 : Energy Conservation Measures For Binh An

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
BA-01	Install VSD for treated water pump	70.767	1,260,000	1,113,922	1,119,492	1.12	478,986

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
BA-02	Replace high pressure lamp 250W/400W to compact lamp 55/105W	2.117	37,700	21,600	21,708	1.7	9,288
BA-03	Install VSD for backwash pump	2.977	53,000	13,957	14,026	3.77	6,002
Total		**75.861**	**1,350,700**	**1,149,479**	**1,155,226**	**1.17**	**494,276**

8.7 Recommendations

Based on the assessments above, it is recommended that all three measures be advanced and funding sought for these.

9 Trung An Water Supply Company

9.1 Plant Description

Trung An Water supply Company has 3 treated water pumping station, capacity of each station is below:

- Go Vap Treated Water Station:
  - Design capacity is 10,000m^3/day.
  - Operational capacity is 5,000m^3/day.
- Binh Tri Dong Treated Water Station:
  - Design capacity is 10,000m^3/day.
  - Operational capacity is 6,500m^3/day.
- Pham The Hien Treated Water Station:
  - Design capacity is 1,200m^3/day.
  - Operational capacity is 400m^3/day.
  - Currently this station acts as a booster pumping station.
  - The treated water basin is 300m^3 of volume.

9.2 Plant Operation

- In phase one, Go Vap pumping station uses eight Pleuger well water pumps.
- In general operation, Go Vap pumping station will only operate three well water pumps. Namely GV4, GV5 and GV6 pumps.
- The flow from the pumps is controlled by a throttling valve.

- Bing Tri Dong pumping station has five well water pumps:
  - Two 25kW EMU well water pumps
  - One 20kW EMU well water pump
  - One 18.5kW Pleuger well water pump
  - One 13.5kW Pleuger well water pump
- In general operation, this station operates three well water pump at 30 m H_2O of pressure and 60-70m^3/h. From the pump curves, the pump's efficiency is 70%.
- These pumps are controlled by throttling valves.

9.3 Baseline Energy Efficiency Index

9.3.1 Go Vap

Average EEI in 2007: 0.57 KWh/m^3. Monthly fluctuations between -8.5% and 33.5% of the average index.
Average EEI in 2008: 0.54 KWh/m^3. Monthly fluctuations between -8.3% and 4.6% of the average index.

The EEI in 2007 and 2008 is stable. The EEI of 2007 is high because the VSD for the treated water pump broke down in August and this pump had to operate by using a throttling valve. This is a direct example of the energy saving obtained by using the VSD, because when the VSD broke down the energy use increased.

9.3.2 Binh Tri Dong

The EEI in 2007 is 0.585 (kWh/m^3)
The EEI in 2008 is 0.596. (kWh/m^3).

Monthly fluctuations for 2007 and 2008 are between -3.5% and 3.7% and between -3.8% and 2.6% respectively. These small fluctuations mean there are no inherent problems with the pumping stations.

The slight increase in EEI from 2007 to 2008 has been identified as being in relation to deteriorating equipment.

9.4 Review of Charging Structures

9.4.1 Energy Supply Arrangements

- Go Vap pumping station operates a 630kVA transformer to supply electricity for the whole station. The station has a manually adjustable capacitor bank with five 10kVAr capacitors.
- Binh Tri Dong pumping station uses a 22kV feed from the national grid. At each well water pump, one 15kV transformer is installed. Below is a list of the transformers:
  - Three 100kVA transformers, total capacity is 300kVA: Supplies electricity for water treatment system.
  - Three 15kVA transformers, total capacity is 45kVA: Supply electricity for well water pumps 2, 3 and 4.
  - All of the transformers have low power factors

9.4.2 Charging Structures

Electricity for the Go Vap pumping station is priced on the basis of three usage periods:

• Peak rate	(09:30 to 11:30) and (18:30 to 22:30)	1,900	(VNĐ/kWh)
• Low rate	(22:30 to 06:00)	540	(VNĐ/kWh)
• Normal rate	All other times	955	(VNĐ/kWh)

Electricity for the Binh Tri Dong pumping station is priced on the basis of three usage periods:

• Peak rate	(09:30 to 11:30) and (18:30 to 22:30)	1,830	(VNĐ/kWh)
• Low rate	(22:30 to 06:00)	510	(VNĐ/kWh)
• Normal rate	All other times	920	(VNĐ/kWh)

9.4.3 Time of Use Analysis

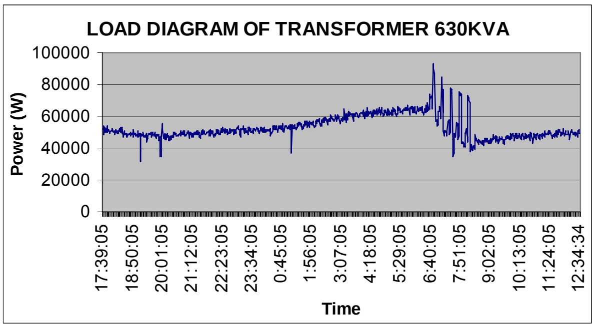
Go Vap already schedules the backwash system to operate during the night at low tariff periods.

9.5 Energy Usage Monitoring

9.5.1 Go Vap

The results of transformer load monitoring are shown in the figure below.

Figure 9-1 : Energy Monitoring Results: Go Vap Transformer

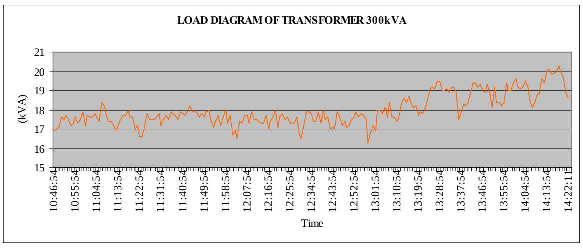


The spikes in usage evident in the early morning are believed to be related to the backwash cycle.

9.5.2 Binh Trung Dong

The results of transformer load monitoring are shown in the figure below.

Figure 9-2 : Energy Monitoring Results: Binh Trung Dong Transformers



Taking into account the distortion of the results being portrayed by the short time frame and condensed y axis, the load on the transformer is relatively constant, as is expected.

9.6 Energy Conservation Measures

In the following sections, energy conservation measures are briefly described. Each measure is uniquely identified with an item number. These numbers include a site identifier. In this case this identifier is TA for Trung An.

9.6.1 ECM-TA-01: Lighting System: Fluorescent Lamp Replacement

The Go Vap pumping station uses 231 T10 fluorescent lamps and electromagnetic ballast. Replacement of the T10 fluorescent lamps and electromagnetic ballast with 1m T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

9.6.2 ECM-TA-02: Lighting System: Fluorescent Lamp Replacement

Binh Tri Dong station uses 58 T10 fluorescent lamps and electromagnetic ballast. Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

9.6.3 ECM-TA-03: Lighting System: High Pressure Lamp Replacement

Binh Tri Dong pumping station uses eight 250W high pressure lamps for public lighting. The replacement of the 250W high pressure lamps to compact 100W lamps will result in energy savings with minimal impact on lighting performance.

9.6.4 ECM-TA-04: Well Water Pump 6: Replacement

Go Vap well water pump 6 is old and in need of replacement. Replacing this pump with a new one will save on energy due to its increased efficiency.

9.6.5 ECM-TA-05: 45kVA Transformer Installation: Install Capacitor Bank

The 45 kVA transformer installation has an average power factor of less than 0.80. Increasing the power factor by installing a capacitor bank will improve the energy efficiency of the transformer and hence save electricity. The improved power factor will be greater than 0.90.

9.6.6 ECM-TA-06: 300kVA Transformer Installation: Install Capacitor Bank

The 300 kVA transformer installation has an average power factor of less than 0.85. Increasing the power factor by installing a capacitor bank will improve the energy efficiency of the transformer and hence save electricity. The improved power factor will be greater than 0.90.

9.6.7 ECM-TA-07: Well Water Pumps GV 4 and 5: Replacement or VSD Installation

Replacing well water pumps 4 and 5 will reduce the energy consumption of the pumping station due to the increased efficiency of the new pumps.

Alternatively, pumps 4 and 5 could be fitted with VSDs to control the pump output and remove the need for the inefficient throttling of the pumps.

Economic assessment of these options indicates that the VSD option is most attractive. This is the measure presented herein.

9.6.8 ECM-TA-08: BT Well Water Pumps: Replacement or VSD Installation

Replacing Binh Trung Dong well water pumps 2, 3 and 4 will reduce the energy consumption of the pumping station due to the increased efficiency of the new pumps.

Alternatively, three VSDs could be fitted to control the output of the pumps and remove the need for the inefficient throttling of the pumps.

Economic assessment of these options indicates that the VSD option is most attractive. This is the measure presented herein.

9.6.9 Summary

Table 9-1 : Energy Conservation Measures For Trung An

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
TA-01	Replace fluorescent lamp T10 to fluorescent lamp T5	2.141	38,115	13,306	13,944	2.73	5,721
TA-02	Replace fluorescent lamp T10 to fluorescent lamp T5	0.609	10,846	4,635	4,668	2.32	1,910
TA-03	Replace high pressure lamp 250W to compact lamp 105W	0.108	1,926	5,011	5,047	0.42	2,070
TA-04	Replace existing well water pump GV6 with a new one with a higher efficiency	7.397	131,700	53,759	56,339	2.34	23,116
TA-05	Install capacitor bank for 45kVA transformer of well water Pump 4	0.247	4,400	7	5,448	0.81	3,900
TA-06	Install capacitor bank for 300kVA transformer	0.247	4,400	43	3,766	1.17	20
TA-07a	Install VSD for well water pump GV4	4.774	85,000	78,449	82,215	1.03	33,733
TA-07b	Install VSD for well water pump GV5	4.774	85,000	88,787	92,338	0.92	38,178

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
TA-08a	Install VSD for BT well water pump 2	1.866	33,217	13,392	13,486	2.46	5.760
TA-08b	Install VSD for BT well water pump 3	4.218	75,096	52,687	53,056	1.42	22,660
TA-08c	Install VSD for BT well water pump 4	1.866	33,217	14,662	14,765	2.25	6,300
Total		**28.247**	**502,917**	**324,738**	**345,072**	**1.46**	**137,613.76**

9.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table identifies these opportunities.

Table 9-2 : Recommended ECMs For Trung An

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
TA-01	Replace fluorescent lamp T10 to fluorescent lamp T5	2.141	38,115	2.73
TA-02	Replace fluorescent lamp T10 to fluorescent lamp T5	0.609	10,846	2.32
TA-03	Replace high pressure lamp 250W to compact lamp 105W	0.108	1,926	0.42
TA-04	Replace existing well water Pump 6 with a new one with a higher efficiency	7.397	131,700	2.34
TA-05	Install capacitor bank for 45kVA transformer of well water Pump 4	0.247	4,400	0.81
TA-06	Install capacitor bank for 300kVA transformer	0.247	4,400	1.17
TA-07a	Install VSD for well water pump GV4	4.774	85,000	1.03
TA-07b	Install VSD for well water pump GV5	4.774	85,000	0.92
TA-08a	Install VSD for BT well water pump 2	1.866	33,217	2.46
TA-08b	Install VSD for BT well water pump 3	4.218	75,096	1.42
TA-08c	Install VSD for BT well water pump 4	1.866	33,217	2.25
Total		**28.247**	**502,917**	

10 Hoc Mon WTP

10.1 Plant Description

The Hoc Mon WTP receives raw water from a network of 40 groundwater bores located in the area. The treated water capacity of the plant in 2008 was recorded as 64,000m^3/day.

As a result of high dissolved iron levels in the raw water, this plant includes an extra step in the treatment process as indicated below:

- Aeration in towers
- Mixing and Flocculation (following dosing with alum to aid flocculation)
- Primary Sedimentation
- Sand Filtration
- Storage

From here, treated water is pumped into the HCMC water system.

10.2 Plant Operation

The Hoc Mon WTP has three sizes of well water pumps: 18.5kW; 30kW; 37kW (GOULDS pumps).

From an assessment of efficiencies it has been found that almost all the well water pumps operate at a medium to low efficiency level (around 70%).

10.3 Baseline Energy Efficiency Index

The EEI for raw water in 2007 was 0.36 (kWh/m^3), with monthly fluctuations between -5.1% and 11.6% of the average.
The EEI for raw water in 2008 was 0.38 (kWh/m^3) with monthly fluctuations between -2.0% and 3.3% of the average.

The increasing EEI may be attributed a number of factors, including:

- Iron deposits in the raw water pipelines resulting in higher energy losses.
- There has been an indication that the water levels in the wells are reducing, thus requiring a greater delivery head from the pumps and increasing power consumption.

The treated water EEI averages in 2007 and 2008 were both 0.56 (kWh/m^3). Monthly fluctuations in the EEI were between -4.9% and 4.0% of the average index and between -2.1% and 3.3% of the average index for 2007 and 2008 respectively.

This plant benefits from its central location and therefore the treated water pumps are not as energy intensive as some other plants.

10.4 Review of Charging Structures

10.4.1 Energy Supply Arrangements

Hoc Mon water treatment plant has 29 transformers to supply electricity for well pumping stations and water treatment areas.

- 18 50kVA (22kV/380V) transformers: supply electricity for pumping stations which have two or three well pumps.
- Eight 25kVA (22kV/380V) transformers: supply electricity for pumping stations which have one well pump.

- Two 1000kVA (22/380V) and one 400kVA transformer: supply electric for water treatment area, two transformers 1000 kVA operate in shifts.

10.4.2 Charging Structures

Electricity for the Hoc Mon WTP is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,830 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 510 (VNĐ/kWh)
- Normal rate All other times 920 (VNĐ/kWh)

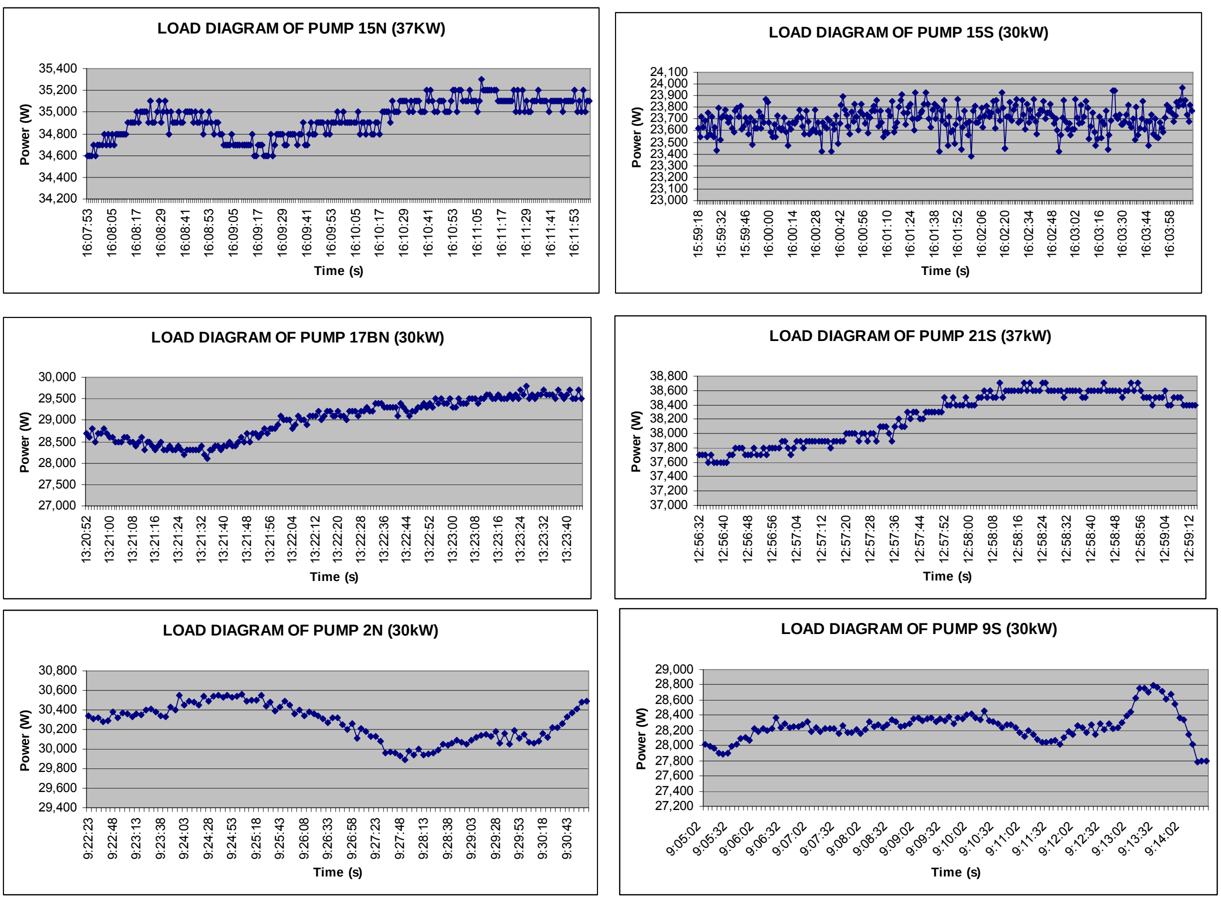
10.4.3 Time of Use Analysis

The process is very constant with little opportunity to schedule operations to avoid the peak tariff periods. Back washing of the sand filters is an area where avoidance of the peak periods may provide some advantages.

10.5 Energy Usage Monitoring

Energy usage was measured and monitored in a number of locations, with some results are shown in the following figures.

Figure 10-1 : Energy Monitoring Results: Hoc Mon Pumps



Whilst these indicate a variation in the power demand, the short time frame and compressed power scale means that these variations are not significant. The operation of the plant and the rate of variation of the well water levels should result in very stable pump operation and power draw. The exception to this is during periods of pump starting/stopping and the like.

10.6 Energy Conservation Measures

10.6.1 ECM-HM-01: Lighting System: Fluorescent Lamp Replacement

Hoc Mon WTP uses 110 T10 fluorescent lamps and electromagnetic ballast. Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

10.6.2 ECM-HM-02: Well Water Pumps: Replacement

The current pumps are quite inefficient and by replacing them with new more efficient pumps a 7.34 % reduction in power can be achieved.

10.6.3 ECM-HM-03: Filter Backwash Process Adjustment

Changing the wash processing to an alternate arrangement (refer to the appended ECC report) using a combination of air and water will reduce the treated water use and reduce electric consumption. In order to apply this process, we have to install a VSD on the backwash pump to adjust the water flow.

10.6.4 Summary

Table 10-1 : Energy Conservation Measures For Hoc Mon

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
HM-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.124	20,010	5,781	5,822	3.44	2,388
HM-02	Replace the existing well water pumps to new pumps with higher efficiency	305.170	5,433,553	1,636,220	1,647,673	3.30	675,759
HM-03	Change the filtration basin washing process	16.063	286,000	471,200	795,274	0.36	202,616
Total		**322.357**	**5,739,563**	**2,113,201**	**2,448,769**	**2.34**	**880,763**

ECM-HM-03 also provides a water saving of 568,830 m^3pa.

10.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. These criteria results in only one ECM being recommended: HM-03.

However, a more detailed study of the remaining life of the pumps referred to in ECM-HM-02 may result in a more beneficial payback period and this should be further considered in conjunction with ongoing operation of the plant.

11 SAWACO Headquarters Offices

11.1 Plant Description

This building was built in 2003 and is located near the centre of Ho Chi Minh City. It is comprised of six office floors and one underground car park floor.

11.2 Plant Operation

This building is predominantly office space with typical occupancy profiles.

11.3 Baseline Energy Efficiency Index

Total area of the building is 4,944 m² and electric consumption is 689,678 kWh in 2008. Therefore, EEI = 139.5 kWh/m²/year.

11.4 Review of Charging Structures

11.4.1 Energy Supply Arrangements

The building uses electricity from a 22kV national grid connection through a 630kVA transformer.

11.4.2 Charging Structures

Electricity for the SAWACO Headquarters Building is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,830 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 510 (VNĐ/kWh)
- Normal rate All other times 920 (VNĐ/kWh)

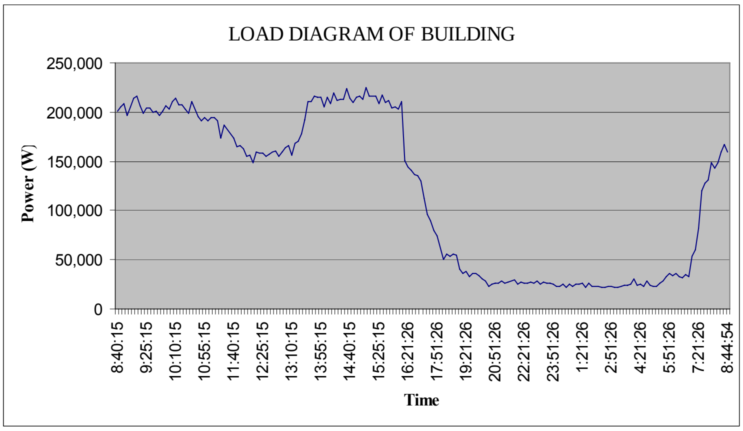
11.4.3 Time of Use Analysis

The energy monitoring undertaken shows that energy usage aligns with a typical office building and that there is little or no opportunity to make use of time-of-use analysis techniques.

11.5 Energy Usage Monitoring

The results of monitoring the electrical load in the building are displayed in the following figure.

Figure 11-1 : Energy Monitoring Results: SAWACO HQ



From the load diagram, it can be seen that this building only operates in during office hours. Overnight use is accounted by some of the lighting system.

11.6 Energy Conservation Measures

11.6.1 ECM-HQ-01: Lighting System: Fluorescent Lamp Replacement

The headquarters office SAWACO uses 848 fluorescent lamps T10 and electromagnetic ballast. Each 1.2m T10 lamp is 50W. Light density is 9.33 W/m^2 (the standard is ≤ 12 W/m^2). Illuminance is 300 lux. Replacement of the T10 fluorescent lamps and electromagnetic ballast by 32W 1.1m T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

11.6.2 ECM-HQ-02: Lighting System: Restroom Lamps

The restroom lights are almost always turned on even though nobody is present in the room. Savings can be made by reminding staff to turn off the restroom lights when the room is not in use.

11.6.3 ECM-HQ -03: Air Conditioner: Replacement

This building has 77 NikkoKendo split-system air conditioners. Cooling capacity is 18,000 BTU/h (5.27kW) and COP_{norm} = 2.85. This COP is lower than the COP standard of the building code ($COP_{standard}$ > 2.93) and significantly lower than units now available on the market. Replacing the air conditioners with new units with a higher COP will save on electricity costs.

11.6.4 ECM-HQ-04: Fresh Air for Building: Improving Flow

Each workroom has a ventilation fan to provide fresh air. These fans operate 8 hours/day. Reducing the operating time of the fans will save energy both from the fans and from the air conditioners.

11.6.5 ECM-HQ-05: Building Envelope: Energy Loss Through Fenestration

Many workrooms do not close the windows when the air conditioner is turned on. This increases the load on the air conditioner and wastes energy. By reminding the staff to close the windows when the air conditioner is operating, energy can be used more efficiently.

11.6.6 ECM-HQ-06: Air Conditioners: Condenser Shading

The condensers are installed in positions such that they are in the sun for either the morning or the afternoon. It has been estimated that by using a sun shade, the condensers will reduce their energy use by 1%-2%.

11.6.7 ECM-HQ-07: Air Conditioners: Temperature Settings

It is recommended that the air conditioners in workrooms and offices be set at 25-26°C. A number of the workrooms had systems set lower than 22°C, with some rooms as low as 16°C. Energy savings can be made by reminding staff to set the air conditioner temperature at 25-26°C.

11.6.8 ECM-HQ-08: Office Equipment and Other Equipment

Computers are left on even though they are not in use. If the computer is not used for a long time the staff should turn off or set it on standby. Electricity consumption of a running computer is 104.5W, in standby 34.4 W.

11.6.9 Building Envelope: Thermal Performance

Based on the building composition, the calculated OTTV is:

- OTTV of walls: 37.92 W/m^2 ≤ OTTVstandard
- OTTV of roof: 15.43 W/m^2 ≤ OTTVstandard

Therefore, this building envelop satisfies the building code. No changes are proposed.

11.6.10 Summary

Table 11-1 : Energy Conservation Measures For SAWACO HQ

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
HQ-01	Replace fluorescent lamp T10 to fluorescent lamp T5	7.858	139,920	37,312	42,816	3.27	16,040
HQ-02	Turn off the lamp in restroom	0	0	5,670	6,506	0	2,440
HQ-03	Replace existing air conditioner to the new one which efficiency is higher	69.791	1,242,620	102,390	117,493	10.58	44,030
HQ-04	Reduce the operate time of ventilation fan	0	0	111,647	132,999	0	48,010
HQ-05	Close the window when operate air conditioner	0	0	24,420	30,403	0	10,500
HQ-06	Install the roof to shade the sun for condenser	0.416	7,400	1,437	1,649	4.49	620
HQ-07	Set temperature of air conditioner at 25 - 26 ^{0}C	0	0	2,797	3,210	0	1,200
HQ-08	Set computer in standby when not in use	0	0	3,334	3,826	0	1,430
Total		**78.065**	**1,389,940**	**289,007**	**338,902**	**4.10**	**124,270**

11.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table shows that in this instance this leaves only no-cost measures as being recommended.

Table 11-2 : Recommended ECMs For SAWACO HQ

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
HQ-02	Turn off the lamp in restroom	0	0	0
HQ-04	Reduce the operate time of ventilation fan	0	0	0
HQ-05	Close the window when operate air conditioner	0	0	0

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
HQ-07	Set temperature of air conditioner at 25 - 26 ^{0}C	0	0	0
HQ-08	Set computer in standby when not in use	0	0	0
Total		**0**	**0**	

12 JS Company Office Zone 3 (Nha Be)

12.1 Plant Description

The company building was constructed in December 2007 and comprises of four floors and one underground floor. Total area is 4096m² (not including the underground floor). However, this company does not use all of the available area. The occupied area is 1,090m2.

12.2 Plant Operation

This building is predominantly office space with typical occupancy profiles.

12.3 Baseline Energy Efficiency Index

Total used area of the building is 1,090 m² and electric consumption is 195,800 kWh in 2008. Therefore, EEI = 180 kWh/m²/year.

12.4 Review of Charging Structures

12.4.1 Energy Supply Arrangements

This building uses electricity from a 320kVA transformer. Electric consumption in the building is divided into as: air conditioner and lighting system.

12.4.2 Charging Structures

The electricity price is 0.1 USD/kWh or 1,750 VND/kWh.

12.4.3 Time of Use Analysis

The flat rate for electricity renders any time-of-use analysis pointless.

12.5 Energy Conservation Measures

12.5.1 ECM-NB-01: Air Conditioner: Replacement

This building uses 50 2HP / 1.5kW split system air conditioners with a COP between 2.5 and 2.9. 14 condensers are installed on the terrace and these condensers stay in the sun from 9am to 4pm. Replacing the air conditioners with new units that have a COP = 4 will dramatically reduce the energy consumption of the building. If possible, moving the condensers into the shade will reduce their energy consumption by about 1%-2%.

12.5.2 ECM-NB-02: Lighting System: Fluorescent Lamp Replacement

- The Nha Be office uses 260 1.2m T10 fluorescent lamps and electromagnetic ballast.
- There are also 70 compact 15W lamps that are operated 7 hours/day.
- Night lighting for the corridors is achieved by 30 0.6m T10 fluorescent lamps and electromagnetic ballast.
- Light density is 14-15 W/m^2 (the standard is ≤ 12 W/m^2) and illuminance is higher than 300 lux.

Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

12.5.3 ECM-NB-03: Building Envelope: Improving Thermal Performance

The building wall material is 200mm thick prefabricated concrete. The window is a bright blue colour with aluminium frames includes a curtain. The material of the roof is prefabricated concrete and ceramic brick.

The calculated OTTV of the wall and roof is:

- OTTV of walls: 60.01 W/m²
- OTTV of roof: 24.71 W/m²

Both OTTVs are higher than the building code standard. Solutions to reducing the OTTV to 36.03 W/m² are:

- Roof: The building should grow some grass or add an air layer for insulation. Cored brick with a 20cm air thickness could be used. The improved roof OTTV will be 17.57 W/m²
- Walls: The building should paint the wall with insulation paint. After use of this paint the OTTV of the wall will be 58.03 W/m²
- Windows: The building should use insulation film. After use of the film the OTTV of the windows will be 38.01 W/m².

12.5.4 Summary

Table 12-1 : Energy Conservation Measures For Nha Be

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
NB-01	Replace existing air conditioner to the new one which efficiency is higher	8.503	151,400	47,416	82,979	1.82	20,389
NB-02	Replace fluorescent lamp T10 to fluorescent lamp T5	3.83	58,450	15,428	26,999	2.16	6,630
NB-03	Improving envelop of the building	11.113	197,868	4,872	8,525	23.21	1,656
Total		**23.446**	**407,718**	**67,716**	**118,503**	**3.44**	**28,675**

12.6 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table identifies these opportunities.

Table 12-2 : Recommended ECMs For Nha Be

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
NB-01	Replace existing air conditioner to the new one which efficiency is higher	8.503	151,400	1.82
NB-02	Replace fluorescent lamp T10 to fluorescent lamp T5	3.83	58,450	2.16
Total		**12.333**	**209,850**	

13 JS Company Office Zone 5 (Gia Dinh)

13.1 Plant Description

The Gia Dinh office building has three floors and is used as an office / workroom. Total area is 1,131 m^2.

13.2 Plant Operation

This building operates during normal office hours and all of the equipment is turned off for the night. Only some of the lighting system remains on during the night.

13.3 Baseline Energy Efficiency Index

Total area of the building is 1,131 m² and electric consumption is 182,642 kWh in 2008. Therefore, EEI = 161.5 kWh/m²/year.

13.4 Review of Charging Structures

13.4.1 Energy Supply Arrangements

The building uses electricity from the national grid at 15kV through a low voltage transformer. The company also has two booster pumps that use electricity from the national grid at 0.4kV.

13.4.2 Charging Structures

Electricity for Gia Dinh is priced on the basis of three usage periods:

- Peak rate (09:30 to 11:30) and (18:30 to 22:30) 1,900 (VNĐ/kWh)
- Low rate (22:30 to 06:00) 540 (VNĐ/kWh)
- Normal rate All other times 955 (VNĐ/kWh)

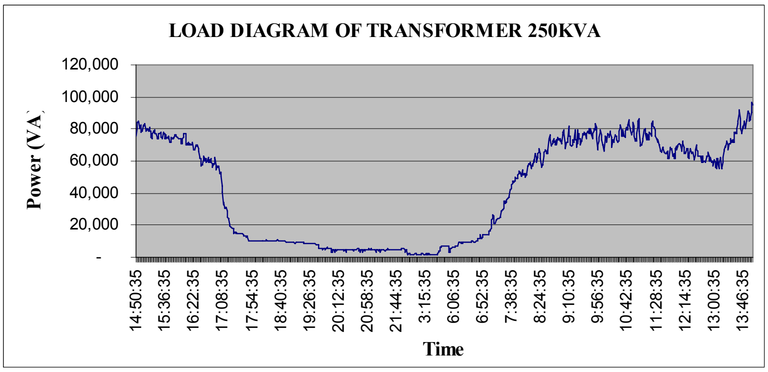
13.4.3 Time of Use Analysis

Energy monitoring shown in the following section indicates a typical day-use profile with no indication of unusual loads.

13.5 Energy Usage Monitoring

Energy usage was measured and monitored on the transformer and the results are shown in the following figure.

Figure 13-1 : Energy Monitoring Results: Gia Dinh Transformer



This shows a typical office usage profile with low night loads and a diurnal variation.

13.6 Energy Conservation Measures

13.6.1 ECM-GD-01: Lighting System: Fluorescent Lamp Replacement

The Gia Dinh office uses 150 T10 fluorescent lamps and electromagnetic ballast. Light density is 6.63 W/m^2 (the standard is ≤ 12 W/m^2) and illuminance is about 300 lux. Replacement of the T10 fluorescent lamps and electromagnetic ballast with T5 fluorescent lamps and electronic ballast will result in energy savings with minimal impact on lighting performance.

13.6.2 ECM-GD-02: Building Envelope: Improving Thermal Performance

- Walls: The building uses a lot of windows and the wall material is 200mm of thick prefabricated concrete. OTTV of the walls is 108.179W/m²
- The roof (terrace): The roof material is 200mm of thick prefabricated concrete. OTTV of the roof is 97.802W/m²

Both OTTVs are higher than the building code standard.

- Roof: The building should install an aluminium roof above terrace to reduce solar gains.
- Walls: The building should use insulating film for the windows to reduce solar gains.

13.6.3 ECM-GD-03: Air Conditioner: Improved Maintenance

The air conditioner is currently maintained once every four months and this long time period leads to dust build-up on the condenser and the evaporator. By improving the maintenance for the evaporator to once every 3-4 weeks and the condenser to once every 5-6 weeks, and by checking the insulation on the refrigerant pipe, the electricity consumption can be reduced by 3%-4%.

13.6.4 ECM-GD-04: Air Conditioner: Replacement

The building has 31 2HP / 1.88kW Toshiba split system air conditioners. Of the 31, seven are new models.

Replacing all of the Toshiba air conditioners with new Panasonic units with a COP = 4.04 will reduce the energy consumption of the building.

13.6.5 ECM-GD-05: Air Conditioner: Temperature Setting

Almost all of the workrooms have their air conditioners set at less than 22°C. This is not necessary for comfortable working conditions and therefore is an unnecessary waste of power. Reminding staff to set the air conditioner temperature at 25-26°C will save electricity.

13.6.6 Summary

Table 13-1 : Energy Conservation Measures For Gia Dinh

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
GD-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.606	28,586	5,700	5,974	4.78	2,451
GD-02	Use the insulation film for glass window	3.370	60,000	6,783	7,109.5	4.22	5,833

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Electricity saving (kWh/year)	Saving cost (x1000VNĐ / year)	Payback time (year)	CO2 reducing (kg/year)
GD-03	Maintenance of air conditioner	0.174	3,100	1,116	1,170	2.65	480
GD-04	Replace existing air conditioner to the new one which efficiency is higher	5.223	93,000	27,900	29,243	3.18	11,997
GD-05	Set temperature of air conditioner at 25 - 26 ^{0}C	0	0	720	755	0	310
Total		**10.373**	**184,686**	**42,219**	**44,251.5**	**4.17**	**21,071**

13.7 Recommendations

Based on the assessments above, it is recommended that all no-cost measures and measures with short payback periods (<3 years) be advanced and funding sought for these. The following table identifies these opportunities.

Table 13-2 : Recommended ECMs For Gia Dinh

ECM No.	Solution	Investment cost (x1000USD)	Investment cost (x1000VNĐ)	Payback time (year)
GD-03	Maintenance of air conditioner	0.174	3,100	2.65
GD-05	Set temperature of air conditioner at 25 - 26 ^{0}C	0	0	0
Total		**0.174**	**3,100**	

14 Consolidated Summary and Recommendations

14.1 ECM Summary

The following table consolidates all ECMs presented in this report.

Table 14-1 : Energy Conservation Measure Summary

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Electricity Saving (kWh/year)	Saving Cost (x1000VND/ year)	Payback Time (year)	C02 reducing (kg/year)
HA-01a	Replace fluorescent lamp 1.2m T10 to fluorescent lamp T5	2.595	46,206	16,688	16,805	2.75	1,176
HA-01b	Replace fluorescent lamp 0.6m T10 to fluorescent lamp T5	0.273	4,862	1,073	1,081	4.50	461
HA-02	Replace mercury high pressure lamp 250W to natri high pressure lamp 100W	1.349	24,012	34,041	34,279	0.70	14,638
HA-03	Repair air conditioner 240,000BTU/h	0.842	15,000	113,291	114,084	0.13	48,715
HA-04	Install VSDs for the raw water pumps	1.526	27,170	2,744	2,763	9.83	1,180
HA-05	Automate the cooling system's air compressors	0.449	8,000	2,628	2,646	3.02	1,130
TD-01	Load shifting for washing filtration basin	0	0	0	38,292	0.00	0
TD-02a	Replace fluorescent lamp T10 to fluorescent lamp T5	5.926	105,509	60,970	61,397	1.72	25,180
TD-02b	Replace fluorescent lamp 0.6 m - T10 to fluorescent lamp 0.6 m - T5	1.625	28,941	10,220	10,292	2.81	4,221
TD-03	Replace the existing chiller water system to the new one which efficiency is higher	31.261	556,600	129,545	130,452	4.27	53,502
TD-04a	Install VSD for cooling water pump	1.526	27,170	22,469	22,626	1.20	9,280
TD-04b	Install VSD for cooling tower water pump	1.928	34,320	29,460	29,666	1.16	12,167
TD-05	Install VSD for treated water pump	1,334.457	23,760,000	9,951,579	8,558,357	2.8	4,279,179
HP-01	Replace fluorescent lamp T10 to fluorescent lamp T5	0.556	9,900	7,096	7,146	1.4	3,000
HP-02	Install VSD for raw water pump 973 kW	1,297	23,100,000	3,993,000	3,825,000	6.0	1,717,000
HP-03	Install one 2500KVA transformer	44.931	800,000	46,496	46,822	17.1	20,000
HP-04	Install VSD for lime solution pump	0.364	6,480	5,606	5,646	1.1	2,000

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Electricity Saving (kWh/year)	Saving Cost (x1000VND/ year)	Payback Time (year)	C02 reducing (kg/year)
TH-01	Replace fluorescent lamp T10 to fluorescent lamp T5	5.108	90,956	17,280	17,401	5.23	7,430
TH-02	Install VSD for treated water pump	1427.127	25,410,000	4,253,520	4,283,295	5.93	1,829,013
TH-03	Install VSD for backwash pump	6.345	112,970	3,807	3,834	29.47	1,637
BO-01	Install VSD for raw water pump	393.148	7,000,000	2,128,680	2,143,581	3.3	9,153,324
BO-02	Use insulation film for windows	3.370	60,000	42,928	43,239	1.4	18,450
BA-01	Install VSD for treated water pump	70.767	1,260,000	1,113,922	1,119,492	1.12	478,986
BA-02	Replace high pressure lamp 250W/400W to compact lamp 55/105W	2.117	37,700	21,600	21,708	1.7	9,288
BA-03	Install VSD for backwash pump	2.977	53,000	13,957	14,026	3.77	6,002
TA-01	Replace fluorescent lamp T10 to fluorescent lamp T5	2.141	38,115	13,306	13,944	2.73	5,721
TA-02	Replace fluorescent lamp T10 to fluorescent lamp T5	0.609	10,846	4,635	4,668	2.32	1,910
TA-03	Replace high pressure lamp 250W to compact lamp 105W	0.108	1,926	5,011	5,047	0.42	2,070
TA-04	Replace existing well water pump GV6 with a new one with a higher efficiency	7.397	131,700	53,759	56,339	2.34	23,116
TA-05	Install capacitor bank for 45kVA transformer of well water Pump 4	0.247	4,400	7	5,448	0.81	3,900
TA-06	Install capacitor bank for 300kVA transformer	0.247	4,400	43	3,766	1.17	20
TA-07a	Install VSD for well water pump GV4	4.774	85,000	78,449	82,215	1.03	33,733
TA-07b	Install VSD for well water pump GV5	4.774	85,000	88,787	92,338	0.92	38,178
TA-08a	Install VSD for BT well water pump 2	1.866	33,217	13,392	13,486	2.46	5.760
TA-08b	Install VSD for BT well water pump 3	4.218	75,096	52,687	53,056	1.42	22,660
TA-08c	Install VSD for BT well water pump 4	1.866	33,217	14,662	14,765	2.25	6,300
HM-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.124	20,010	5,781	5,822	3.44	2,388
HM-02	Replace the existing well water pumps to new pumps with higher efficiency	305.170	5,433,553	1,636,220	1,647,673	3.30	675,759

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Electricity Saving (kWh/year)	Saving Cost (x1000VND/ year)	Payback Time (year)	C02 reducing (kg/year)
HM-03	Change the filtration basin washing process	16.063	286,000	471,200	795,274	0.36	202,616
HQ-01	Replace fluorescent lamp T10 to fluorescent lamp T5	7.858	139,920	37,312	42,816	3.27	16,040
HQ-02	Turn off the lamp in restroom	0	0	5,670	6,506	0	2,440
HQ-03	Replace existing air conditioner to the new one which efficiency is higher	69.791	1,242,620	102,390	117,493	10.58	44,030
HQ-04	Reduce the operate time of ventilation fan	0	0	111,647	132,999	0	48,010
HQ-05	Close the window when operate air conditioner	0	0	24,420	30,403	0	10,500
HQ-06	Install the roof to shade the sun for condenser	0.416	7,400	1,437	1,649	4.49	620
HQ-07	Set temperature of air conditioner at 25 - 26 0C	0	0	2,797	3,210	0	1,200
HQ-08	Set computer in standby when not in use	0	0	3,334	3,826	0	1,430
NB-01	Replace existing air conditioner to the new one which efficiency is higher	8.503	151,400	47,416	82,979	1.82	20,389
NB-02	Replace fluorescent lamp T10 to fluorescent lamp T5	3.83	58,450	15,428	26,999	2.16	6,630
NB-03	Improving envelop of the building	11.113	197,868	4,872	8,525	23.21	1,656
GD-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.606	28,586	5,700	5,974	4.78	2,451
GD-02	Use the insulation film for glass window	3.370	60,000	6,783	7,109.5	4.22	5,833
GD-03	Maintenance of air conditioner	0.174	3,100	1,116	1,170	2.65	480
GD-04	Replace existing air conditioner to the new one which efficiency is higher	5.223	93,000	27,900	29,243	3.18	11,997
GD-05	Set temperature of air conditioner at 25 - 26 ^{o}C	0	0	720	755	0	310
Total		**5,100.055**	**90,803,620**	**24,859,481**	**23,849,427.5**		**18,889,352**

From this list, an investment plan can be developed that prioritises investment in the ECMs that present the most compelling case for advancement. The following table summarises the level of capital investment required for four levels of ECM:

- No cost and immediate payback
- Short term payback (<3 years)
- Medium term payback (3 to 5 years)
- Longer term payback (>5 years)

Table 14-2 : No Cost Measures

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
TD-01	Load shifting for washing filtration basin	0	0	0.00
HQ-02	Turn off the lamp in restroom	0	0	0
HQ-04	Reduce the operate time of ventilation fan	0	0	0
HQ-05	Close the window when operate air conditioner	0	0	0
HQ-07	Set temperature of air conditioner at 25 - 26 0C	0	0	0
HQ-08	Set computer in standby when not in use	0	0	0
GD-05	Set temperature of air conditioner at 25 - 26 ^oC	0	0	0
Total		**0**	**0**	

Table 14-3 : Short Term Payback Measures

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
HA-01a	Replace fluorescent lamp 1.2m T10 to fluorescent lamp T5	2.595	46,206	2.75
HA-02	Replace mercury high pressure lamp 250W to natri high pressure lamp 100W	1.349	24,012	0.70
HA-03	Repair air conditioner 240,000BTU/h	0.842	15,000	0.13
TD-02a	Replace fluorescent lamp T10 to fluorescent lamp T5	5.926	105,509	1.72
TD-02b	Replace fluorescent lamp 0.6 m - T10 to fluorescent lamp 0.6 m - T5	1.625	28,941	2.81
TD-04a	Install VSD for cooling water pump	1.526	27,170	1.20
TD-04b	Install VSD for cooling tower water pump	1.928	34,320	1.16
TD-05	Install VSD for treated water pump	1,334.457	23,760,000	2.8
HP-01	Replace fluorescent lamp T10 to fluorescent lamp T5	0.556	9,900	1.4
HP-04	Install VSD for lime solution pump	0.364	6,480	1.1
BO-02	Use insulation film for windows	3.370	60,000	1.4
BA-01	Install VSD for treated water pump	70.767	1,260,000	1.12
BA-02	Replace high pressure lamp 250W/400W to compact lamp 55/105W	2.117	37,700	1.7
TA-01	Replace fluorescent lamp T10 to fluorescent lamp T5	2.141	38,115	2.73
TA-02	Replace fluorescent lamp T10 to fluorescent lamp T5	0.609	10,846	2.32
TA-03	Replace high pressure lamp 250W to compact lamp 105W	0.108	1,926	0.42
TA-04	Replace existing well water pump GV6 with a new one with a higher efficiency	7.397	131,700	2.34
TA-05	Install capacitor bank for 45kVA transformer of well water Pump 4	0.247	4,400	0.81
TA-06	Install capacitor bank for 300kVA transformer	0.247	4,400	1.17
TA-07a	Install VSD for well water pump GV4	4.774	85,000	1.03
TA-07b	Install VSD for well water pump GV5	4.774	85,000	0.92

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
TA-08a	Install VSD for BT well water pump 2	1.866	33,217	2.46
TA-08b	Install VSD for BT well water pump 3	4.218	75,096	1.42
TA-08c	Install VSD for BT well water pump 4	1.866	33,217	2.25
HM-03	Change the filtration basin washing process	16.063	286,000	0.36
NB-01	Replace existing air conditioner to the new one which efficiency is higher	8.503	151,400	1.82
NB-02	Replace fluorescent lamp T10 to fluorescent lamp T5	3.83	58,450	2.16
GD-03	Maintenance of air conditioner	0.174	3,100	2.65
Total		**1,484.239**	**26,417,105**	

Table 14-4 : Medium Term Payback Measures

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
HA-01b	Replace fluorescent lamp 0.6m T10 to fluorescent lamp T5	0.273	4,862	4.50
HA-05	Automate the cooling system's air compressors	0.449	8,000	3.02
TD-03	Replace the existing chiller water system to the new one which efficiency is higher	31.261	556,600	4.27
BO-01	Install VSD for raw water pump	393.148	7,000,000	3.3
BA-03	Install VSD for backwash pump	2.977	53,000	3.77
HM-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.124	20,010	3.44
HM-02	Replace the existing well water pumps to new pumps with higher efficiency	305.170	5,433,553	3.30
HQ-01	Replace fluorescent lamp T10 to fluorescent lamp T5	7.858	139,920	3.27
HQ-06	Install the roof to shade the sun for condenser	0.416	7,400	4.49
GD-01	Replace fluorescent lamp T10 to fluorescent lamp T5	1.606	28,586	4.78
GD-02	Use the insulation film for glass window	3.370	60,000	4.22
GD-04	Replace existing air conditioner to the new one which efficiency is higher	5.223	93,000	3.18
Total		**752.875**	**13,404,931**	

Table 14-5 : Longer Term Payback Measures

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
HA-04	Install VSDs for the raw water pumps	1.526	27,170	9.83
HP-02	Install VSD for raw water pump 973 kW	1,297	23,100,000	6.0
HP-03	Install one 2500KVA transformer	44.931	800,000	17.1
TH-01	Replace fluorescent lamp T10 to fluorescent lamp T5	5.108	90,956	5.23
TH-02	Install VSD for treated water pump	1427.127	25,410,000	5.93
TH-03	Install VSD for backwash pump	6.345	112,970	29.47

ECM No	Solution	Investment Cost (x1000USD)	Investment Cost (x1000VND)	Payback Time (year)
HQ-03	Replace existing air conditioner to the new one which efficiency is higher	69.791	1,242,620	10.58
NB-03	Improving envelop of the building	11.113	197,868	23.21
Total		**2,862.941**	**50,981,584**	