Energy Profiling for Demand Side Management Using the CISCO EnergyWise Product

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ABSTRACT

This report evaluates the functional capabilities of Cisco's EnergyWise software by gathering information of the functionality desired by the stakeholders, UBC Campus Sustainability, Operations and ECE, by developing a test plan according to this information, and by conducting product research and case studies. Methods of investigation include stakeholder meetings, conference call with Cisco representatives, white paper research, conducting case studies and researching the "Cisco EnergyWise Management Help" document. EnergyWise saves energy by minimizing the waste. The function "Poicy" sets a specified usage pattern to optimize energy usage. Because of security concerns of other integration methods, Windows machines offer "EnergyWise Helper" that UBC may benefit from. The function "Scenario Reports" provide expected energy savings given a scenario. Scenarios have four configuration items: time-based pattern, extrapolation, power factor, and power limit. The results of a case study shows that Kaiser and MacLeod buildings have a small percentage of IT energy consumption from the building's total, 1.07% and 1.48% respectively. Also, the maximum energy saving by setting the power state to standby of all devices attached to the network switches in Kaiser is 7.83%. These results from the case studies suggest that Kaiser and MacLeod buildings does not significantly benefit from using EnergyWise. However, the integration of computers will result in much higher energy savings. Therefore some more case studies must be conducted regarding the usage pattern of computers in the future to appropriately evaluate the functional capabilities of EnergyWise.

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LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

BMS: Building Management System

ECE: Electrical and Computer Engineering

EMS: Energy Management System

UBC: University of British Columbia

WinRM: Windows Remote Management

WMI: Windows Management Instrumentation

ABSTRACT

This report evaluates the functional capabilities of Cisco's EnergyWise software by gathering information of the functionality desired by the stakeholders, UBC Campus Sustainability, Operations and ECE, by developing a test plan according to this information, and by conducting product research and case studies. Methods of investigation include stakeholder meetings, conference call with Cisco representatives, white paper research, conducting case studies and researching the "Cisco EnergyWise Management Help" document. EnergyWise saves energy by minimizing the waste. The function "Poicy" sets a specified usage pattern to optimize energy usage. Because of security concerns of other integration methods, Windows machines offer "EnergyWise Helper" that UBC may benefit from. The function "Scenario Reports" provide expected energy savings given a scenario. Scenarios have four configuration items: time-based pattern, extrapolation, power factor, and power limit. The results of a case study shows that Kaiser and MacLeod buildings have a small percentage of IT energy consumption from the building's total, 1.07% and 1.48% respectively. Also, the maximum energy saving by setting the power state to standby of all devices attached to the network switches in Kaiser is 7.83%. These results from the case studies suggest that Kaiser and MacLeod buildings does not significantly benefit from using EnergyWise. However, the integration of computers will result in much higher energy savings. Therefore some more case studies must be conducted regarding the usage pattern of computers in the future to appropriately evaluate the functional capabilities of EnergyWise.

1.0 INTRODUCTION

This report presents an investigation of the functionality of Cisco's EnergyWise software for demand side management. EnergyWise is an Energy Management System (EMS) software product from Cisco that specializes in monitoring and controlling the IT equipment. The objectives of this project are to gather information on the functionality desired by stakeholders, to develop a test plan according to this information, and to conduct product research and case studies to carry out the test plan in order to evaluate the software.

Due to the physical infrastructure limits of electrical lines and the growth in power demand of University of British Columbia (UBC), the campus must reduce its electrical load by approximately 4 MW by the year 2015. Therefore, the UBC departments of IT and Utilities are evaluating EMS products that can assist UBC in achieving its goal. This project plays a significant role in helping the university make a more informed decision in choosing the most suitable software system because it evaluates one of the EMS software products, EnergyWise.

This project focuses on providing information on device functionality of EnergyWise and energy saving strategies in Kaiser and MacLeod buildings. The stakeholders who provided information on desired functionality of the software are the department members of UBC Campus Sustainability, Operations, and Electrical and Computer Engineering (ECE). Although providing the procedures to implement the EMS software is beyond the scope of this project, some difficulties related to implementation, including the security concerns in connecting Windows machines, are discussed in this report. Also, the information on cost and carbon savings will not be presented.

This report divides into the primary sections, “Methodology of Investigation,” “Investigation of EnergyWise,” “Recommendations,” and “Conclusion”.

2.0 METHODOLOGY OF INVESTIGATION

This section explains the different methods used in completing this project. It includes the procedure, the purpose, and the relevancy to the project of each method.

2.1 Stakeholder Meetings

Three different UBC departments, Campus Sustainability, Operations and ECE, are interested in this project. Campus Sustainability wishes to obtain energy saving strategies and hopes to use the software as a global EMS that monitors and controls the UBC's integrated Building Management System (BMS) and the "ION" database, which monitors the total energy consumption from electricity, hot water, steam, and other energy sources. On the other hand, Operations and ECE are more interested to know the functional capabilities of the software. To focus on each stakeholder's needs, three separate meetings were held.

The main purpose of these meetings is to gather information on desired functions of EnergyWise. Some desired functions include peak shaving, load shedding, and the unification of different databases. Some uncertainties were raised in the meetings, which include how the software saves energy and how energy is measured in devices. These meetings played a significant role in the initial phase of the project as they provided prioritized research ideas and important unknowns of the software. Research results regarding these ideas and unknowns will be covered in the section "Investigation of EnergyWise."

2.2 Conference Call with Cisco Representatives

After sufficient information was gathered from the stakeholder meetings, it was evident that a meeting or a conference call with someone from Cisco is essential to acquire more knowledge of EnergyWise. Since Cisco's offices are based in eastern Canada, far from the UBC campus, a conference call was more reasonable, and two employees from the company hosted the call. They gave instructions of using some functions of the software by the method of remote computer access and answered the questions prepared by two members from UBC departments and myself. This call has effectively increased the quality of this project as it helped me understand the functional capabilities of the software, develop a test plan for case studies, and find answers to some uncertainties that stakeholders had. Important findings are presented later in this report.

2.3 White Paper Research

On the company website, Cisco provides a few white papers of EnergyWise. These discuss the case studies conducted by the company to show the functional capabilities of the product. The purpose of white paper research is to re-enact the suggested energy saving strategies in our test environment to reproduce the claimed energy savings using our equipment data. The one with its case study completed in a similar test environment as the one in UBC was researched with higher priority to investigate the most applicable functions. Unfortunately, the claimed 30 percent energy savings in computers were not reproducible in our test environment as no computers were implemented until the final phase of this project [1]. However, the claim was helpful in foreseeing the potential savings, and it suggests implementing as many computers as possible.

One disadvantage of researching white papers was that many documents did not provide any limitations of the software, such as the security concerns of implementing Windows machines.

However, there was one white paper that was essential in finding the limitation of controlling the power state of voice over internet protocol (VoIP) phones. These limitations will be explained in “Investigation of EnegyWise” section.

2.4 Conducting Case Studies

In investigating the EnergyWise product, the user experience was the best method to learn about its capabilities. By using a read-only account, which does not allow the user to change important settings of the program, many features of the software were explored, including the functions “Device Segments” and “Scenario Reports.” By using these functions and monitoring the energy consumption of the devices, case studies were conducted. The results of all case studies are presented in “Investigation of EnergyWise.”

Conducting case studies was an essential part of evaluating the EnergyWise system. The goal of these studies was to see if the software can fulfill UBC’s needs when implemented in the university’s environment. As the university wants to reduce its electrical load by approximately 4MW, it was necessary to conduct a case study to find out how much the energy consumption of the IT equipment is compared to the total energy consumption of the building. Bounded by the scope of this project, this study analyzed the energy consumption of Kaiser and MacLeod buildings. The analysis of Henry Angus building was also included to show the result of having more IT equipment.

As EnergyWise offers a useful tool to analyze the potential energy savings of the building, another case study was conducted to evaluate it. Although the most potential savings are in utilizing the computers [1], none of them were implemented in our system. Therefore, VoIP phones were chosen for this case study. Network switches and wireless local area network access points (WLANAPs) were also available for this purpose, but they may have larger undesirable impact of controlling their power state. This case study shows how much energy can be saved by changing the usage pattern of VoIP phones.

2.5 “Cisco EnergyWise Management Help” Document

The “Cisco EnergyWise Management Help” document, available within the program, clearly explains all functionality of the product, including its capabilities and limitations, the different ways of integrating devices, and the measurement methods of energy consumption. By referring to this document when exploring the software, many unclear procedures were explained and many questions were answered, such as the meaning of measurement index and the difference between the four types of “Scenario Reports.” Due to the nature of the read-only account, some functions were not available in the software, but this help document provided the sufficient information on them to be evaluated. It is highly recommended that the user refers to this document when getting familiarized with the software or when troubleshooting a problem.

3.0 INVESTIGATION OF ENERGYWISE

This section provides the results and findings of this project through the methods described in the previous section. It also includes the detailed description of the functionality of EnergyWise.

3.1 Saving Energy Through EnergyWise

During the stakeholder meetings, many questions were asked about how EnergyWise can save energy by monitoring and controlling the IT equipment. The energy savings come from minimizing the waste of energy. To achieve this optimization, a function of EnergyWise called "policy" is significantly useful as it can change the power state of various devices all at once. The selection of desired devices to be affected by the policy can be made easily with "importance" and "priority" values. Every device has an importance value to be set. When the user creates a policy, a priority value has to be entered. To the devices of importance value that is less than or equal to the priority value of a policy, the policy is applied. On the other hand, if the importance value of the device is greater than the priority value, the policy is skipped over. This feature provides a fine selectivity of equipment during the implementation of energy usage rules. There are three types of policies: time-based, event-based, and location-based. When a time-based policy is created, the user can set a time schedule that the policy will operate on. An event-based one is executed when a specific event happens, such as a peak demand of energy. The user can create a location-based policy if he/she wishes to execute it based on his/her location. For example, a computer turns off when the user exits his/her office.

Another important question raised during one of the stakeholder meetings was on how the energy is measured in the device. EnergyWise provides another excellent feature for this purpose called "TruJoule," a technology that accurately calculates the power consumption of a device. Some devices report their exact power consumption; however, many do not. TruJoule's accuracy comes from collecting specific information even to the component level of a device. Once this information is collected, the software finds the appropriate energy profile in the TruJoule database. Every device has its own “Power Quality Index,” which shows the accuracy of energy consumption measurement. This varies from sensor measurements to measurements from the energy profiles available from the database, and these profiles may be verified, unverified, or low quality depending on the device. If an energy profile is not available for a specific device, the device information can be sent to the Cisco server to be available in later updates, or a manual power measurement can be performed. The procedures of these are beyond the scope of this project.

The unification of different databases is a function of EnergyWise desired by the stakeholder, Campus Sustainability. The possibility of this function was mentioned during the conference call with the representatives of Cisco. Many BMS’s provide files in the form of comma-separated values (CSV) that can be monitored by EnergyWise. However, the control of these databases is not yet fully implemented in the software and is currently under design consideration. The ability to monitor the devices that uses a power plug or a battery was questioned by the stakeholder, UBC Operations. One of the employees of Cisco mentioned that this function is not yet available in EnergyWise.

3.2 Functionality of EnergyWise

3.2.1 Integration of devices

Table 1. Integration methods of different devices

Device	Integration Method
Windows machine	Can be integrated through one of WMI[1], WinRM[2], or "EnergyWise Helper"
Macintosh machine	Can be integrated using SSH.
Printers	Can be connected indirectly through the parent computer or directly if they are network printers.
Monitors	Can be connected indirectly via the parent computer.

[1]Windows Management Instrumentation.

[2]Windows Remote Management.

As shown in Table 1, Windows machines can be integrated through three different methods. However, there are security concerns of integrating using WMI and WinRM. Both methods require an admin credential, and some users may not want to provide this as it may lead to allowing more control of the system than they anticipated. UBC IT is also concerned for this matter, and therefore an excellent alternative, "EnergyWise Helper" is highly recommended. Although it requires an installation, it eliminates the security concerns and provides more accurate data, such as the actual idle time of the computer and the detailed specifications of the devices attached it [2]. For Macintosh machines, an SSH authentication key can be used instead of a password. One limitation of integrating the monitor is that it is assumed to be powered off if the computer that it is connected to is off. More information about the security concerns of Windows machines and the procedures of device integration can be found in the section "Device Type" under "General Concepts" in the document, "Cisco Management Help."

3.2.2 Device Segments

“Devise Segments” is a function available in EnergyWise that helps the user to group together the desired devices. To create a device segment, the user can either choose the appropriate categories of the desired devices to include in the segment or write a “Device Query Language” to include them. If the user wants to analyze the energy consumption of all VoIP phones in Kaiser building, a device segment can be set to include only the specified VoIP phones, rather than all the ones connected to the software. This function was extremely useful to this project when conducting case studies as only the specific devices were selected to be analyzed.

3.2.3 Scenario Reports

In EnergyWise, “Scenario Reports” generates an analysis of expected energy savings according to the user’s specified scenario, and it uses the real baseline data of implemented devices to evaluate the scenario’s effectiveness. To create a scenario reports, a device segment and a date range need to be selected for the report to be based on. This device segment is not necessarily the one that the scenario is applied, rather it is the one that the baseline data is obtained from. Also, one or more scenario configuration items and a device segment to apply the scenario need to be selected. A scenario can be configured in four different ways as follows:

- **Time-based pattern**: Used to obtain the expected energy savings by changing the power state of the devices according to the desired time schedule.
- **Extrapolation:** Used to foresee the change in energy consumption by increasing or decreasing the number of specified devices.
- **Power Factor:** Allows the user to see the impact of limiting the power usage of the devices to the desired percentage.
- **Power Limit:** Allows the user to see the anticipated energy savings by limiting the maximum power usage of the devices to the desired Watts.

In this project, “Scenario Reports” plays a significant role in evaluating EnergyWise as it is used to conduct case studies.

3.3 Case Studies

3.3.1 Energy consumption of IT equipment

Table 2. IT energy consumption from Kaiser and MacLeod buildings (data range is from Jan. 1st to Mar. 18th, 2014)

Building	Total Electrical Energy Consumption (kWh)	Total IT Energy Consumption (kWh)	Percentage of IT Consumption[1]
Kaiser	368,823.00	3,958	1.07%
MacLeod	152,726.25	2,253	1.48%
Henry Angus	1,093,767.50[2]	44,862	4.10%

[1]Percentages are of the total electrical energy consumption.

[2]The total electrical energy consumption of Henry Angus building includes the consumption of David Lam Library.

To evaluate EnergyWise, it is necessary to know the percentage of the energy consumption of IT equipment from the total electrical energy consumption. The reason is that the software focuses on conserving the IT consumption. Therefore, a cast study is conducted to find the percentages from Kaiser, MacLeod, and Henry Angus buildings. The total electrical energy consumption was obtained from the “ION” database, and the IT consumption was obtained from EnergyWise. Table 2 shows that Kaiser, MacLeod and Henry Angus buildings have 1.07, 1.48, and 4.10 percentages, respectively. The low percentages of Kaiser and MacLeod are expected because the buildings have more experimental labs that are non-IT energy consumers. The two buildings consist of network switches, VoIP phones, WLANAPs, and switch interfaces. As shown in Figures 1 and 2, network switches consume most energy compared to other integrated devices.

Therefore, Henry Angus building has a higher percentage because it has a larger number of network switches.

Based on the results of Table 2, one may conclude that the energy consumption of IT equipment is negligible. However, the low percentages are because the computers in these buildings are not integrated with the EMS. According to the white paper [1], up to 30 percent savings of the computer's energy can be achieved just by utilizing them, which does not affect the performance of the machines. This suggests that the integration of the computers is crucial to see the full potential of EnergyWise.

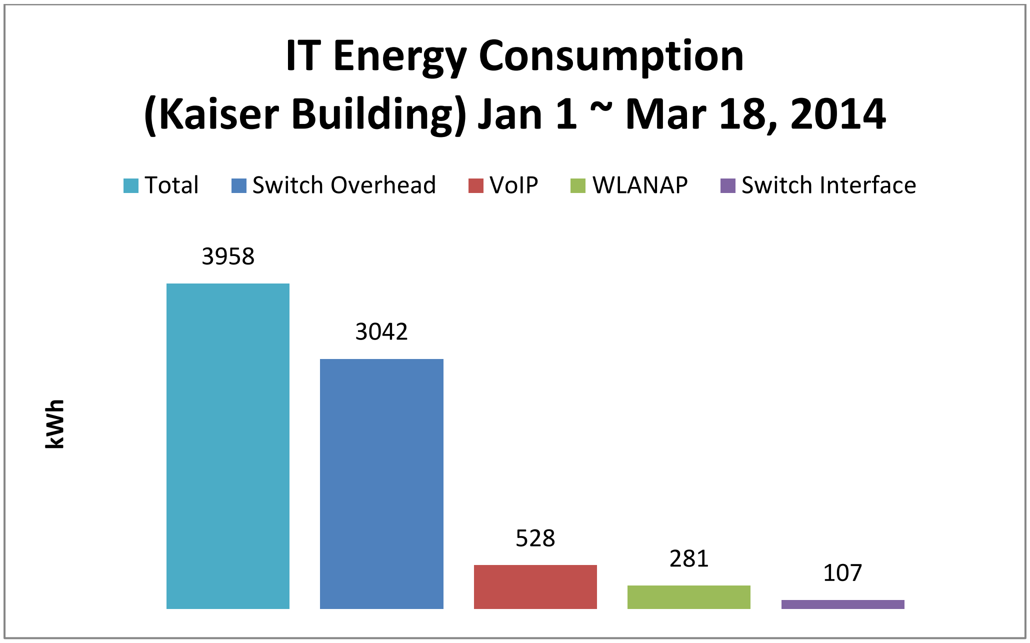

Figure 1. Energy consumption of all integrated devices in Kaiser building

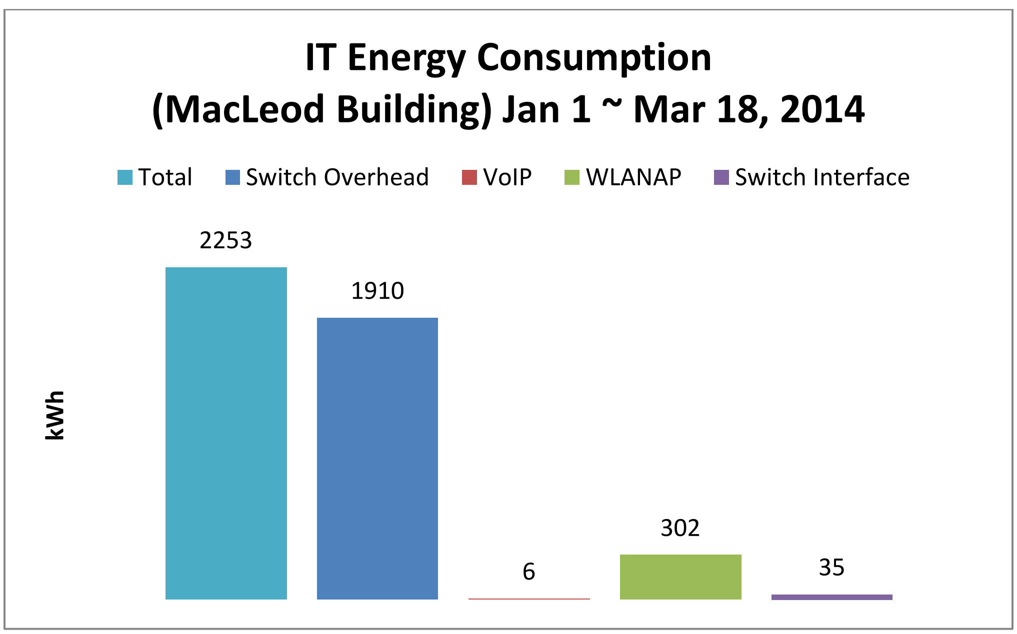

Figure 2. Energy consumption of all integrated devices in MacLeod building

3.3.3 Expected Energy Savings

Table 3. Expected savings generated using "Scenario Reports" (data range is from Jan. 1st to Mar. 18th, 2014)

Building	**Scenario Configuration**	**Device Segment**	**Energy Saving (kWh)**	**Percentage of Energy Saving[1]**
Kaiser	Time-based[2]	All child devices	160	4.04%
		VoIP Phones	40	1.01%
	Time-based & Power Factor[3]	All child devices	310	7.83%
		VoIP Phones	140	3.54%
MacLeod	Time-based	All child devices	120	5.33%
		VoIP Phones	0	0%
	Time-based & Power Factor	All child devices	160	7.10%
		VoIP Phones	0	0%

[1]Percentages are of the total IT energy consumption from the specified building.

[2] All time-based scenarios have the power state setting of "standby" with the time pattern of "7:00pm to 7:00am each day."

[3]All power factor scenarios set the power consumption of the specified devices to 80% of the actual value.

As seen in Figures 1 and 2 above, switch overhead consumes most energy in Kaiser and MacLeod buildings. However, a network switch is not flexible in changing its power state. The same is true for a WLANAP and a switch interface. Therefore, a case study of changing the usage pattern of VoIP phones was conducted, assuming that its power state can be set to "standby." However, this assumption is incorrect as the power state of VoIP phones can only be set to on or off [3].

In this case study, the expected energy savings are obtained from the function "Scenario Reports." Scenario configurations of the time-based pattern and the power factor are used to model the most realistic and applicable case to UBC's environment. In the time-based scenarios, the power state of all child devices or VoIP phones are set to standby from 7:00pm to 7:00am each day.

Considering that VoIP phones do not consume much energy (see Fig.1 and 2), small percentages of savings are expected. This expectation matches the results in Table 3. The percentages are zero for the VoIP phones in MacLeod because the consumption of two phones is negligibly small. Because these percentages are low for all scenario cases, implementing EnergyWise is not beneficial unless the computers are integrated. As previously mentioned in this report, if the computers are integrated, the IT energy consumption will show a much larger number, resulting in more energy savings when they are utilized. Several case studies of changing the usage pattern of the computers must be conducted to see the full potential capabilities of EnergyWise.

As some network switches in Kaiser and MacLeod buildings may be decommissioned in the future to move the network infrastructure to the new data centre in Pharmacy building, a case study using the extrapolation will show the expected savings of this migration. However, all attempted scenarios with extrapolation showed no energy savings for unknown reasons. This scenario configuration item should be investigated further as it can provide useful information for UBC.

4.0 CONCLUSION

This report investigated the functionality of Cisco's EnergyWise software by collecting the information on functions desired by the stakeholders, UBC Campus Sustainability, Operations and ECE, by developing a test plan according to this information, and by conducting product research and case studies to evaluate the software. The results of a case study showed that the energy consumption of IT equipment in Kaiser and MacLeod buildings are 1.07% and 1.48% of the building's total consumption, respectively. Also, another case study showed that if the power state of all child devices of network switches in Kaiser is set to standby from 7:00 pm to 7:00 am every day, and if they are consuming 80% of the actual consumption, the building will see 7.83% energy savings at most. Considering that the results from these case studies are low, EnergyWise is not beneficial for UBC. However, if computers, which have high potential energy savings when utilized, are implemented, energy savings are expected to be significant. Therefore, the integration of computers is highly recommended and some case studies regarding the change of the usage pattern of computers must be conducted to fully evaluate the capabilities of EnergyWise.

5.0 REFERENCES

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