THE IMPACT OF INDEPENDENT VARIABLES TO THE ENERGY CONSUMPTION IN AN INDUSTRY

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THE IMPACT OF INDEPENDENT VARIABLES TO THE ENERGY CONSUMPTION IN AN INDUSTRY

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A report submitted

in fulfillment of the requirements for the degree of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this project report entitled “The Impact of Independent Variables to the Energy Consumption in an Industry” is the result of my own work except as cited in the references.

Signature : …….

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Date : …….

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : …….

Supervisor : Mr. Mohamed Hafiz bin Md Isa

Date : …….

DEDICATION

To my beloved mother, father and siblings.

ABSTRACT

Energy sector has major impact in industry as industry sector is the second largest energy consumer. Various variables contribute to the consumption of energy in industry. There wide range of purpose of using energy such as process and assembly, heating and cooling process, and steam. Energy conservation measure (ECM) is implemented to improve energy consumption. Option C in M&V plan is applied in this study. Reducing energy consumption lead toward better, healthier and sustainable environment. By identifying and analysing independent variables that contribute higher consumption of energy in an industry, energy saving can be improved. Unwanted or insignificant variables can be reduced by evaluating the variables to define which variables shows better relation in consumption of energy in the building. Data for three year will be collected. Baseline model will be constructed based on first year data as implementation of ECM will be done in the second and third year. Multiple linear regression and correlation analysis is implemented to find the best statistical model to calculate saving. Correlation analysis is done to identify which independent variables have stronger relationship with the energy consumption. Independent variables that have positive relationship will be selected to construct statistical models. Possible statistical model will be made based on the selected independent variables in correlation analysis. After that, the possible statistical model will undergo regression analysis. The best statistical model will be selected based on the criteria and requirement stated. The best statistical model also acts as the baseline model. The equation obtained for the baseline model is y = 70938.781+1686.660FUR+25918.578UCT-445.488WHB. Based on the baseline model, estimated energy consumption can be calculated. Saving can be determine based on the difference between estimated energy consumption and actual energy consumption. As for the conclusion, stronger relationship of independent variables and energy consumption give great impact toward total energy consumption.

ABSTRAK

Sektor tenaga memberi impak besar dalam industri kerana sektor industri merupakan pengguna tenaga kedua terbesar. Pelbagai pembolehubah menyumbang kepada penggunaan tenaga dalam industri. Terdapat pelbagai tujuan menggunakan tenaga seperti proses dan pemasangan, proses pemanasan dan penyejukan, dan stim. Langkah pemuliharaan tenaga dilaksanakan bagi meningkatkan penggunaan tenaga.Pilihan C dalam pelan M&V digunakan dalam kajian ini. Pengurangan penggunaan tenaga membawa ke arah persekitaran yang lebih baik, sihat dan mampan. Dengan mengenalpasti dan menganalisa pembolehubah bebas yang menyumbang penggunaan tenaga yang lebih tinggi dalam industri, penjimatan tenaga dapat dipertingkatkan. Pembolehubah yang tidak diingini atau tidak penting boleh dikurangkan dengan menilai pembolehubah untuk menentukan pembolehubah yang menunjukkan hubungan yang lebih baik dalam penggunaan tenaga di dalam bangunan. Data selama tiga tahun akan dikumpulkan. Model asas akan dibina berdasarkan data tahun pertama kerana pelaksanaan langkah pemuliharaan tenaga akan dilakukan pada tahun kedua dan ketiga. Pelbagai regresi linear dan analisis korelasi dilaksanakan untuk mencari model statistik terbaik untuk mengira penjimatan. Analisis korelasi dilakukan untuk mengenal pasti pembolehubah bebas yang mempunyai hubungan yang lebih kukuh dengan penggunaan tenaga. Pembolehubah bebas yang mempunyai hubungan positif akan dipilih untuk membina model statistik. Pelbagai model statistik akan dibuat berdasarkan pembolehubah bebas yang terpilih dalam analisis korelasi. Selepas itu, analisis regresi akan dijalankan terhadap model-model statistik tersebut. Model statistik terbaik akan dipilih berdasarkan kriteria dan keperluan yang dinyatakan. Model statistik terbaik juga bertindak sebagai model asas. Persamaan yang diperolehi untuk model asas adalah y = 70938.781 1686.660FUR 25918.578UCT-445.488WHB. Berdasarkan model asas, anggaran penggunaan tenaga boleh dikira. Penjimatan boleh ditentukan berdasarkan perbezaan antara anggaran penggunaan tenaga dan penggunaan tenaga sebenar. Kesimpulannya, hubungan pembolehubah bebas yang lebih kukuh dengan penggunaan tenaga memberi kesan yang besar terhadap penggunaan tenaga secara menyeluruh.

ACKNOWLEDGMENTS

In the name of Allah S.W.T, the Most Beneficent and the Most Merciful. All praise to Allah the Almighty for giving me the strength, courage, guidance, and patient in completing this project report. First and foremost, I would like to express my gratitude and acknowledgement to my supervisor, Mr. Mohamed Hafiz bin Md Isa for his supervision, encouragement and support in completing this project. His guidance in this project provides me with more insights about the project.

I also would like to express my gratitude to my friends especially Muhammad Fahim Ikhwan bin Najamuddin, Noraiman Hakim bin Mahime and Nurnazwin Ilmiah binti Khaidir for sharing their knowledge, guidance, and assistance to complete this project. A special thanks to my lecturers for teaching and sharing their knowledge. I also would like to thank Dr Noryani binti Muhamad for her guidance and knowledge in statistical analysis that help me to finish the project. A very special thanks to my beloved parents, Mr. Huzaimi bin Shaari and Mrs. Rosnani binti Mohd Salleh, and my siblings: Aina Firzanah binti Huzaimi, Nazrul Fauzan bin Huzaimi, Muhammad Irfan bin Huzaimi, Fatin Nur Hadirah binti Huzaimi and Nazrul Wafiy bin Huzaimi for their moral support and encouragement in completing this degree. Lastly, I would like to thank everyone who had been directly or indirectly involves in this project. May Allah bless us all.

TABLE OF CONTENTS

DECLARATION i
APPROVAL ii
DEDICATION iii
ABSTRACT iv
ABSTRAK v
ACKNOWLEDGMENTS vi
TABLE OF CONTENTS vii
LIST OF TABLES ix
LIST OF FIGURES x
LIST OF ABBEREVATIONS xi
LIST OF SYMBOLS xii
CHAPTER 1 1
INTRODUCTION 1
1.1 Background of Study 1
1.2 Problem Statement 3
1.3 Objectives 4
1.4 Scope of Project 4
CHAPTER 2 5
LITERATURE REVIEW 5
2.1 International Performance Measurement and Verification Protocol (IPMVP) 5
2.2 M&V Option. 6
2.2.1 Option A (Retrofit isolation with key parameter measurement) 7
2.2.2 Option B (Retrofit isolation with all parameter measurement) 7
2.2.3 Option C (Utility data analysis) 7
2.2.4 Option D (Calibrated simulation) 8
2.3 Energy Saving Companies (ESCO) 8
2.4 Energy Performance Contract (EPC) 10
2.5 Energy Management and Energy Audit 11
2.6 Correlation and Regression 13
2.7 Related Previous Works on Energy Avoided by Measurement & Verification 13
CHAPTER 3 17

METHODOLOGY 17
3.1 Introduction 17
3.2 IPMVP Framework of Calculating Energy Savings 19
3.3 Data Collection 19
3.4 Data Analysis 20
3.4.1 Multiple Regression Analysis 20
3.4.2 Correlation Analysis 22
3.5 Energy Consumption Analysis Using SPSS 22
3.6 Adjustment Data 26
3.7 Independent Variables 26
CHAPTER 4 28
RESULTS AND DISCUSSION 28
4.1 Introduction 28
4.2 Industry General Information. 29
4.2.1 Overall Process Flow Chart of Production of Products 29
4.3 Preliminary Results 31
4.3.1 Independent Variables 31
4.3.2 Dependent Variable 36
4.4 Baseline Model 36
4.4.1 Correlation Coefficient between Independent Variables and Total Energy Consumption 38
4.4.2 Scatter Plot 38
4.4.3 Selection of Possible Variables after Correlation 45
4.4.4 Possible Statistical Model based on the Correlation Analysis. 46
4.4.5 Statistical Analysis of The Independent Variables Selected 47
4.5 Estimation of Energy Consumption and Saving 52
4.5.1 Reporting Period and Energy Saving in 2018 52
4.5.2 Reporting Period and Energy Saving in 2019 55
CHAPTER 5 59
CONCLUSION AND RECOMMENDATION 59
REFERENCES 61
LIST OF APPENDICES 64
APPENDIX A 64

LIST OF TABLES

Table 1: Pearson Correlation Coefficient (Abela, 2019)..... 22
Table 2: CUT data collected for three years. 31
Table 3: DEB data collected for three years. 32
Table 4: FUR data collected for three years. 32
Table 5: OFFAL data collected for three years. 33
Table 6: PUR data collected for three years. 34
Table 7: UCT data collected for three years. 34
Table 8: WHB data collected for three years. 35
Table 9: Total energy consumption data collected for three years. 36
Table 10: Table of statistical analysis criteria (Noryani et al.,2018.) 37
Table 11:Correlations between total energy consumption and independent variables 38
Table 12: Table of correlation to select variables. 45
Table 13: List of Possible Statistical Model..... 46
Table 14: Tabulate data of regression analysis by SPSS. 49
Table 15: Tabulate data of regression analysis using SPSS. 50
Table 16: Total energy saving calculation for 2018. 53
Table 17: Total energy saving calculation for 2019. 56
Table 18: Percentage of energy saving in 2018 and 2019. 58

LIST OF FIGURES

Figure 1: Retrofit isolation Vs Whole-facility methods. 6
Figure 2: Saving illustration based on M&V plan 8
Figure 3: Flowchart of MLR Analysis 18
Figure 4: First page of SPSS 23
Figure 5: Linear Regression Step in SPSS 23
Figure 6: Dialogue Box of Linear Regression 24
Figure 7: Table of Model Summary 25
Figure 8: ANOVA Table 25
Figure 9: Coefficients Table 26
Figure 10: Basic Process of Production of Products at FY Food 29
Figure 11: Nugget Production Process 29
Figure 12: Sausage Production Process 30
Figure 13: Burger Meat Production Process 30
Figure 14: Scatter plot of total energy consumption and CUT. 39
Figure 15: Scatter plot of total energy consumption and DEB. 40
Figure 16: Scatter plot of total energy consumption and FUR 40
Figure 17:Scatter plot of total energy consumption and OFFAL 41
Figure 18: Scatter plot of total energy consumption and PUR 42
Figure 19: Scatter plot of total energy consumption and UCT 43
Figure 20: Scatter plot of total energy consumption and WHB 44
Figure 21: Single linear regression analysis by SPSS 47
Figure 22: Multiple linear regression analysis by SPSS 48
Figure 23: Trend of energy consumption over the year 2018. 54
Figure 24: Trend of energy consumption over the year 2019. 57

LIST OF ABBEREVATIONS

ST	Suruhanjaya Tenaga
EPC	Energy Performance Contracting
ESCO	Energy Service Companies
MAESCO	Malaysia Association of Energy Service Companies
M&V	Measurement and Verification
IPMVP	International Performance Measurement and Verification Protocol
EVO	Efficiency Valuation Organization
ECM	Energy Conservation Measures
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers

LIST OF SYMBOLS

R^2	=	Coefficient of determination
r	=	Correlation coefficient
b_0	=	Intercept of independent variables slope
b_1	=	First independent variable slope
b_2	=	Second independent variable slope
X_1	=	first independent variable
X_2	=	Second independent variable
y_i	=	Baseline energy
$\hat{y}_i$	=	Adjusted baseline energy

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Generally, energy is very essential in today's world as it is needed to grow, evolve, and survive. In a developing country, energy needed is growing in quantities to aid economic and social progress as well as to create a better life quality. Energy sector has a major impact in Malaysia's industry sector. In Malaysia, the industrial sector is the second largest energy consumer. Major consumers of electric energy in industry are electric motor, pumps, and air compressors. The industrial sector uses about 39% of total energy use in 2005 (Saidur, et al., 2009). Malaysia's economy grows rapidly at 5% in 2005 and energy is the main contributor. In an industry, energy used in a wide range of purposes like process and assembly, heating and cooling process, steam and cogeneration, and lighting.

In Malaysia, the government has set up a statutory body that is responsible for regulating the energy sector. Energy Commission or also known as Suruhanjaya Tenaga objectives: to balance the need of consumers, provide energy to ensure safe and reliable supply at reasonable prices, protect public interest, and foster economic development as well as competitive markets in an environmentally sustainable manner (Suruhanjaya Tenaga, 2019). Suruhanjaya Tenaga has three main role which are economic regulation, technical regulation, and safety regulation.

Based on Suruhanjaya Tenaga (ST), final electricity consumption for industrial building had an increment of 21% from year 2014 to 2017 (Suruhanjaya Tenaga,

2011). This statistic indicated that the level of sustainable energy management in industry is lacking. In order to reduce the consumption of energy, energy conservation is necessary. One of the ways to conserve energy is to improve efficiency by technological advancements and improving the operation and maintenance.

Moreover, the National Green Technology Policy was introduced by the sixth Malaysia's Prime Minister YAB Dato' Sri Mohd Najib Tun Abdul Razak on 24th July 2009 (KeTTHA, 2017), and four pillars have been highlighted which are energy, environment, economy and social. Green technology is used to preserve the natural environment and resources by the development and application of equipment, product and systems. Green technology is selected as the main driver to encourage sustainable development and accelerate economy.

Furthermore, the Eleventh Malaysia Plan (2016-2020) comes out with the initiatives to enhance energy management system in industry and commercial building by the introduction of Energy Performance Contract (EPC). As energy has been mentioned in both policy and plan, it strongly shows that energy management is very crucial to a better future for the nation.

In this research, a study to identify the variables that impacting the energy consumption in industrial building is conducted. Regression and correlation analysis is applied to indicate suitable independent variables and to construct best statistical model based on the variables selected. Saving or increment of energy usage will be calculated based on the best statistical model.

1.2 Problem Statement

Generally, this project involves the energy consumption of an industrial building. Energy used in food processing company to operate is in a massive amount. There are several parts that need to be focussed to reduce energy consumption. By identifying and analysing the independent variables that affect the energy consumption of the building, the energy saving can be improved. The variables are a crucial element that contribute to the total energy consumption of the building. Unwanted or insignificant variables can be reduced by evaluating the variables to define which variables show better relation in consumption of energy in the building. Implementation of energy efficiency services is needed in order to conduct energy saving.

Energy efficiency service give huge advantage of consumption savings at the beginning of the contract term. However, at the end of the contract, energy saving achieved is not sustain and lesser than promises. A weak measurement and verification plan (M&V plan) may lead to low energy savings toward the end of the project. Other study shows the same problem have been recognised in this study which is:

- Household sector in Jordan used high amount of energy consumption. Factors affecting the usage of energy was analysed and energy consumption is estimated. Impact of the independent variables is determined by using regression (Alrahamneh, 2011).

A few objectives have been indicated to implement in this project. These objectives are stated in the next sub-topic.

1.3 Objectives

The objectives of this project are:

i. To collect data on independent and dependent variables.

ii. To calculate energy consumption using MLR analysis.

iii. To identify and analyse energy consumption in industry.

1.4 Scope of Project

This project covers the idea to identify energy consumption in a food processing industry located in Perak. FY Food Processing Sdn. Bhd. provides fresh processed chicken and frozen food made from chicken. Whole facility energy measurement is used in this project. Option C in M&V plan is implemented in this study for saving determination. Measurement is documented continuously during a length of reporting certain period. Independent variables that have strong relationship with the energy consumption will be analysed using multiple linear regression and correlation. Baseline model is calculated based on the first year of data collection. The data of all independent variables has been collected monthly for three years. A few examples of variables were considered to be audited which are amount of raw chicken meat that been cut into parts, amount of raw chicken that been debone, amount of raw materials that undergo further process into product ready to cook, amount of offal processed, product undergo refrigeration, uncooked chicken texture, and amount of water used in heat boiler to produce steam and for further process.

CHAPTER 2

LITERATURE REVIEW

2.1 International Performance Measurement and Verification Protocol (IPMVP)

International Performance Measurement and Verification Protocol (IPMVP) was published by Efficiency Valuation Organization (EVO) to improve savings in energy, water efficiency projects, renewable energy projects, and demand management (Efficiency Valuation Organization, 2012). A few activities have been conducted by IPMVP such as documenting ordinary terms and methods to evaluate performance of efficiency projects. Besides that, methods with different levels of cost and accuracy are offered for whole facility and individual energy conservation measures. IPMVP also applicable to a wide range of facility. M&V plan content are being define for each facility. In each energy saving project, a qualified professional must develop a M&V plan (Efficiency Valuation Organization, 1994-2020). IPMVP serves as the framework for M&V procedures by providing four M&V options. IPMVP aims are to estimate the possibility of energy saving from measurements, simulations, and calculations. Baseline model assessment is used in IPMVP.

M&V plan must be conducted before selection of option in IPMVP. M&V is the process to determine actual saving using measurement. There are a few M&V activities such as data gathering and screening, suitable estimations, development of a calculation technique, maintenance and meter installation of calibration, computations and reporting of measured data, third party verification of reports and quality

guarantee. M&V can effectively help in energy saving increment as well as to achieve efficiency of resources and environmental objectives (Energy Efficiency Council, 2015). M&V is applied to calculate energy efficiency project.

2.2 M&V Option.

M&V approaches are divided into two general types which are retrofit isolation and whole facility. There are four option in M&V provided by IPMVP which are Option A, B, C and D. Option A and B are retrofit isolation while option C and D are based on whole-facility M&V methods (Department of Energy U.S, 2008). Retrofit isolation techniques consider the affected equipment or system independent for the rest of facility but whole-facility techniques consider the total usage of energy. Figure below shows the differences of the energy conservation measures (ECM) boundary. Energy used inside the boundary must be measured.

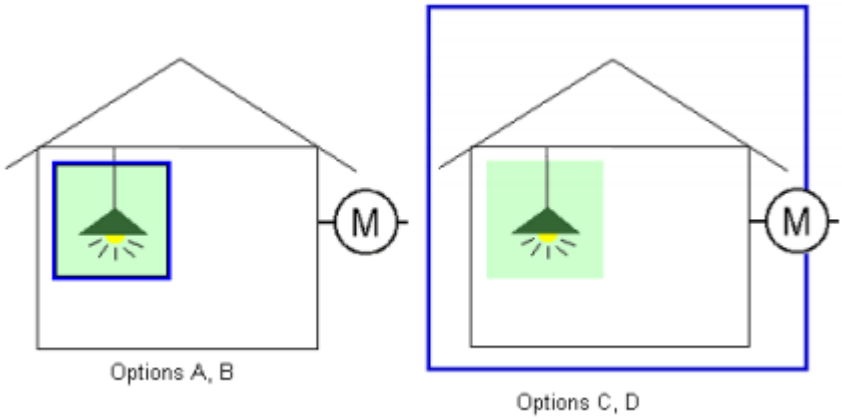

Figure 1: Retrofit isolation versus Whole-facility methods.

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2.2.1 Option A (Retrofit isolation with key parameter measurement)

Option A determines saving by measuring key parameters. The accuracy level of this option is inversely proportional to the complexity of the measure. Short-term measurement during baseline and post-installation periods, estimations and calculations can be used to determine actual saving. Option A may be least accurate in determining savings, but it is the easiest and cheaper method.

2.2.2 Option B (Retrofit isolation with all parameter measurement)

Option B determines energy use by measuring all parameters during the performance period. By relating metered energy used with key independent variables, baseline models are developed. Savings is calculated by comparing the energy used during performance period with the generated baseline model. Despite providing greatest accuracy in calculating savings, cost in this method is expensive.

2.2.3 Option C (Utility data analysis)

Option C determines energy savings by using whole building utility data. Savings is calculated through analysis of utility data and independent variables that effecting the energy consumption. Total energy savings can be measured by developing statistical model. Energy used is predicted by regression models based on the independent variables of the project. The energy used predicted by the baseline model is being compared to the actual energy used in the performance period to analyse savings.

2.2.4 Option D (Calibrated simulation)

Option D determines savings by simulating energy usage of entire facility. This option is useful when there is no baseline exist. All data required must be collected to create the simulation models of existing building. Building subsystem metering need to be included in M&V activities for baseline and performance period to get end-use data for calibration of model. Savings calculation can be more accurate if more site-specific data is included but the costs will be greater.

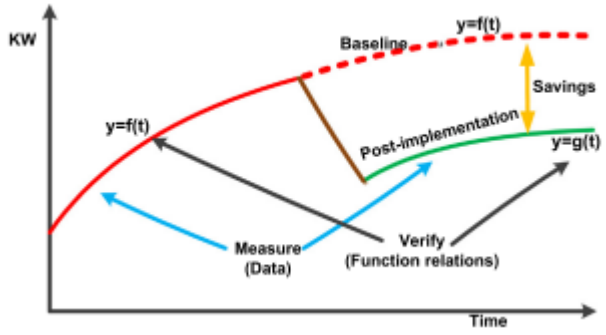

Figure 2: Saving illustration based on M&V plan

2.3 Energy Saving Companies (ESCO)

ESCO is a firm that offers solutions for attaining energy cost reductions by implementing energy-efficiency projects. EPC is provided by Energy Service Company (ESCO) to employ various energy measures and technologies to reduce energy consumption. ESCO is a commercial business which provides a wide range of energy solution and project management (Tariq, Othman, Wahab, & Ebrahim, 2018). ESCO is one of the most effective and affordable method as it provides a complete installation of energy saving. In Malaysia, resources for the ESCO industry are provided by Malaysia Association of Energy Service Companies (MAESCO). A client

will be provided a turn-key solution for the energy efficiency project by employing an ESCO.

Retrofitting, energy infrastructure subcontracting, energy conservation, power generation, electric supply, and risk management as well as complete installation of energy saving project is the example of services provided by ESCO. ESCOs are basically different based on the concept of performance-based contracting from other energy efficiency improvement agency. ESCO's services are related as Energy Service Providing Companies (ESPCs). ESCO in Malaysia offers performance-based contracts in order to improve energy efficiency while searching for alternative energy sources.

In addition, ESCO also offers services in audit, advisory, finance, monitoring, and procurement. A single contract that offers all services for energy efficiency projects is provided by ESCO to their clients, namely the Energy Performance Contract (EPC). Energy services company play an important role in promoting energy efficiency around the world (Vine, 2005). In Malaysia, most energy service companies are a member of the Malaysia Association of Energy Service Companies, MAESCO. All members provide services correlated to energy efficiency and energy services in general (MAESCO, 2012). For a project to run, financial is supported by the clients and ESCO will provide performance guarantees. ESCO will obtain payment if the energy saving projects are delivered as expected. Poor project management and delaying in resolving technical problems are factors that required more time to complete a project. A renegotiate of contract between ESCO and facility's owner will be requested to achieve savings (Mahat, 2016).

2.4 Energy Performance Contract (EPC)

Energy Performance Contract (EPC) is a profit-sharing agreement of energy efficiency project between ESCO and a client who manage a facility. The fundamental of the agreement is that ESCO offers skill and knowledge on recognition and evaluation of the energy saving potential. ESCO received it payment if the energy saving project are delivered as expected. ESCO will undertake risks related to accomplishing the savings promised by the project. EPC is an innovative method of contracting that can be used in any facility and grant facility owners to upgrade ageing and inefficient assets (Jensen, 2017). The measures in an EPC project enhanced the performance of the buildings as well as savings of energy. Temperature, lighting, and ventilation systems are being improved by using EPC. Through a long-term EPC contract, an increasing of saving is produced by energy efficiency measures (ICF International, 2007).

There are a few steps to prove savings from EPC. Firstly, before project implementation, three steps required which are allocating project obligations, developing a specific M&V plan for project, and defining the baseline. Next, commissioning of installed equipment and systems during the implementation. Post-installation verification activities must be conducted as well. After project implementation, regular-interval verification activities must be performed during the performance period.