Jeong-Jin Kang
Edward J. Rothwell
Nguyen Nang Dinh
Nguyen Thanh Thuy
Gyoo Seok Choi
Nguyen Ha Nam

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# CONTENTS

# Best Practice on Cost Estimation and Priority with Use Case Point (UCP) for Renewable Energy System

[1]Bo kyung Park, [2]So Young Moon, [3]Woo Sung Jang, [4]Ki Du Kim, [*5]R. Young Chul Kim

*[1,2,3,*5]SE Lab, Dept. of CIC(Computer and Information Communications), Hongik University Korea*
*[4]Telecommunications Technology Association, Korea*
*[1,2,3]{park, msy, jang}@selab.hongik.ac.kr, [*5]bob@hongik.ac.kr, [4]kdkim@tta.or.kr*

***Abstract***

*Countries around the world are installing monitoring systems to constantly manage the renewable energy system. Yet, due to different installation standards and interoperability modes, it is challenging to manage the existing systems. Thus, a monitoring system for integrated management needs to be developed. To develop a successful monitoring system, the cost and effort estimation of a system development will be necessary. It is effective to perform these activities at an earlier stage of a project. We propose a method of effort estimation for software based on the use case analysis. The proposed method enables the effort estimation per use case.*

***Keywords:*** *Renewable Energy Monitoring System, Use Case Point, Effort Estimation, Use Case Priority, Use Case Verification.*

## 1. Introduction

As an alternative solution for recent energy problems, countries around the world are paying much attention to renewable energy. In Korea, the cumulative photovoltaic installation has increased from 21MW(2006) to 1,019MW(2012)[1]. Yet, each renewable energy has unique properties and electric power production varies with climate change. Therefore, each country has installed a monitoring system to manage the renewable energy. Yet, the structural heterogeneity among the existing monitoring systems hinders real-time information integration and interoperability of data. An integrated monitoring system needs developing to address this problem.

Developing a successful monitoring system requires estimating cost and effort spent on system development. It is effective to estimate cost and effort at an earlier stage of a project [2]. Previous studies extracted and verified the requirements priority based on use case point (UCP)[3]. Yet, this method does not yield effort estimation results. Therefore, a systematic and rational planning of a system proved difficult in previous studies. To address this problem, the present paper applies the use case point to the effort estimation of software and to the renewable energy monitoring system. This paper consists of the following chapters. Chapters 2 describes the structure of renewable energy monitoring system based on literature review. Chapter 3 elucidates the effort estimation method for monitoring system using the use case point. Finally, chapter 4 presents the conclusion and suggestion for future studies.

## 2. Related Works

The existing renewable energy monitoring system is limited to a particular domain. Likewise, each company develops a distinct monitoring system. Yet, to provide an efficient monitoring service, the interface for diverse renewable energy property information should be standardized and integrated. A standardized

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and integrated system is easily interoperable with the existing renewable energy system. Figure 1 shows the structure of the renewable energy monitoring system using the standard interface.

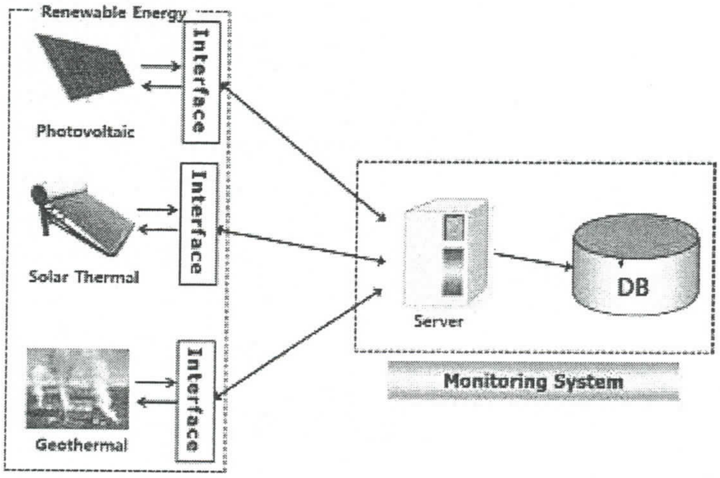


**Figure 1. Renewable Energy Monitoring System**

## 3. Software Effort Estimation based on Use Case Point (UCP)

Prior to developing the renewable energy monitoring system, we are to apply the estimation based on the use case point. The use case point (UCP) was originally developed by Gustav Karner [4]. In this method, actors and use cases in a use case diagram are used to measure the number of use cases, sizes and complexities [5]. However, the existing UCP has the following problems: (i) The UCP does not indicate the structure of a specific use case or how to write it. Therefore, use case models and specification can vary. (ii) The UCP does not allow for the *Include* and *Extends* relations of use cases. To address this problem, we subdivide the types and weights of actors and use cases. Also, if a use case involves an *include* or *extend* relation, we added a weight of 0.25 to the use case, which is based on Periyasamy's method [6]. Figure 2 is a use case diagram of the renewable energy monitoring system.

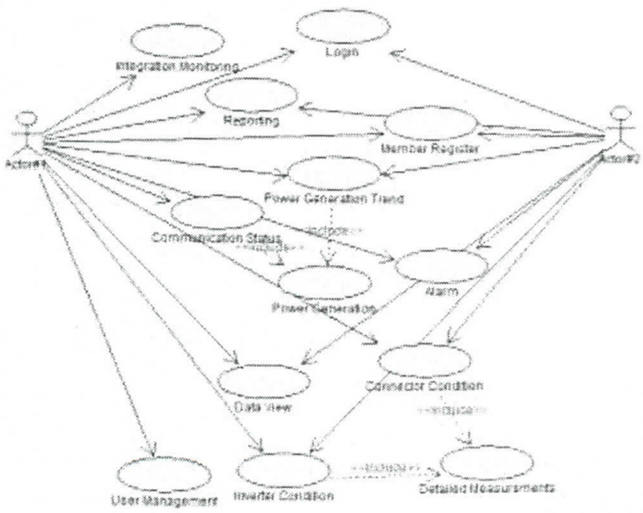


**Figure 2. Renewable Energy Monitoring System Use Case Diagram**

In this chapter, we follow the steps 1 to 7 of the estimation to describe the effort estimation for the monitoring system. In this method, the existing methods of extracting and verifying the requirements priority are improved [3]. Table I shows the values of unadjusted actor weight (UAW) and unadjusted use case weight (UUCW).

**Table 1. Calculated UAW and UUCW**

| No | Use Case | Unadjusted Actor Weight(UAW) | | | Unadjusted UseCase Weight(UUCW) | | | | | UUCP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (User) Actor Weight | (Manager) Actor Weight | Actor Weight | Basic Flow | Alternative Flow | Exceptional Flow | Total Transaction | Use Case Weight | |
| UC1 | Login | 1 | 1 | 2 | 1 | 0 | 1 | 2 | 0.5 | 3 |
| UC2 | Power Generation Trend | 1.5 | 1 | 2.5 | 1 | 5 | 1 | 7 | 3 | 5.5 |
| UC3 | Power Generation | 1 | 1 | 2 | 1 | 6 | 1 | 8 | 3 | 5 |
| UC4 | Detailed Measurements | 1 | 1.5 | 2.5 | 1 | 3 | 0 | 4 | 2 | 4.5 |
| UC5 | Integration Monitoring | 2 | 3 | 5 | 1 | 2 | 1 | 4 | 2 | 7 |
| UC6 | Data View | 0.5 | 1 | 1.5 | 1 | 1 | 0 | 2 | 0.5 | 2 |
| UC7 | Reporting | 0.5 | 1 | 1.5 | 1 | 1 | 0 | 2 | 0.5 | 2 |
| UC8 | Alarm | 2 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 4 |
| UC9 | User Management | No Use | 2 | 2 | 1 | 4 | 1 | 6 | 2 | 4 |
| UC10 | Member Register | No Use | 2 | 2 | 1 | 1 | 0 | 2 | 0.5 | 2.5 |
| UC11 | Communication Status | No Use | 2 | 2 | 1 | 7 | 2 | 10 | 3 | 5 |
| UC12 | Inverter Condition | 0.5 | 0.5 | 1 | 1 | 0 | 0 | 1 | 0.5 | 1.5 |
| UC13 | Connector Condition | 0.5 | 0.5 | 1 | 1 | 2 | 0 | 3 | 1 | 2 |
| UC14 | Equipment Management | 0.5 | 0.5 | 1 | 1 | 0 | 0 | 1 | 0.5 | 1.5 |
| UC15 | Evaluation Result | 0.5 | 0.5 | 1 | 1 | 0 | 0 | 1 | 0.5 | 1.5 |
| UC16 | Sensor Management | 0.5 | 0.5 | 1 | 1 | 1 | 0 | 2 | 0.5 | 1.5 |

In Table 2, TCF5, TCF6 and TCF8 measure 0 and thus are excluded.

**Table 2. Calculated UCP, Priority and Total Estimate**

| No | Use Case | TCF1 | TCF2 | TCF3 | TCF4 | TCF7 | TCF9 | TCF10 | TCF11 | TCF12 | TCF13 | TCF Value | EF1 | EF3 | EF4 | EF5 | EF7 | EF8 | EF Value | UCP | Priority | Total Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 1 | 1 | 1 | 0.5 | 1 | 1 | 1 | 1 | 1 | | 1.5 | 0.5 | 0.5 | 1 | -1 | 2 | | | | |
| UC1 | Login | 0 | 1 | 1.5 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 5 | 1 | 0 | 1 | 0 | 1 | 1 | 3 | 38 | 15 | 750 |
| UC2 | Power Generation Trend | 1 | 3 | 1.5 | 2 | 3 | 1 | 2 | 0 | 0 | 1 | 14 | 0 | 1 | 2 | 3 | 2 | 1 | 5 | 347 | 3 | 6930 |
| UC3 | Power Generation | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 0 | 0 | 1 | 17 | 0 | 2 | 2 | 2 | 2 | 1 | 4 | 340 | 4 | 6800 |
| UC4 | Detailed Measurements | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 10 | 0 | 1 | 2 | 2 | 3 | 2 | 5 | 203 | 8 | 4050 |
| UC5 | Integration Monitoring | 3 | 3 | 2 | 1 | 3 | 1 | 1 | 0 | 1 | 1 | 17.5 | 1 | 3 | 3 | 3 | 4 | 2 | 8 | 919 | 1 | 18375 |
| UC6 | Data View | 0 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 1 | 2 | 1 | 2 | 6 | 72 | 11 | 1440 |
| UC7 | Reporting | 0 | 2 | 2 | 1 | 4 | 0 | 0 | 2 | 0 | 0 | 9 | 0 | 2 | 1 | 2 | 2 | 2 | 6 | 99 | 9 | 1980 |
| UC8 | Alarm | 0 | 4 | 1 | 0 | 3 | 1 | 1 | 0 | 2 | 0 | 10.5 | 1 | 1 | 2 | 3 | 3 | 2 | 7 | 294 | 5 | 5880 |
| UC9 | User Management | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 1 | 4 | 0 | 1 | 9 | 144 | 7 | 2880 |
| UC10 | Member Register | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 5 | 1 | 2 | 0 | 1 | 0 | 1 | 6 | 69 | 12 | 1375 |
| UC11 | Communication Status | 1 | 2 | 1 | 0.5 | 2 | 1 | 1 | 2 | 0 | 2 | 13.5 | 0 | 2 | 2 | 3 | 2 | 4 | 11 | 743 | 2 | 14850 |
| UC12 | Inverter Condition | 0 | 3 | 2 | 0 | 4 | 3 | 0 | 2 | 0 | 1 | 13 | 1 | 1 | 1 | 2 | 2 | 2 | 7 | 127 | 8 | 2535 |
| UC13 | Connector Condition | 0 | 2 | 3 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 9 | 0 | 1 | 1 | 2 | 2 | 2 | 5 | 90 | 10 | 1800 |
| UC14 | Equipment Management | 0 | 2 | 2 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 8 | 0 | 1 | 1 | 1 | 1 | 1 | 5 | 36 | 16 | 720 |
| UC15 | Evaluation Result | 0 | 2 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 9.5 | 0 | 1 | 1 | 1 | 1 | 1 | 3 | 43 | 14 | 855 |
| UC16 | Sensor Management | 1 | 2 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 11.5 | 0 | 1 | 1 | 1 | 1 | 1 | 3 | 52 | 13 | 1035 |

## 4. Conclusion

The present paper estimates the efforts needed to develop the renewable energy monitoring system using the improved use case point. To that end, this paper rectifies the existing studies to extract the values for SW effort estimation. Also, the problems associated with UCP (use case point) are rectified to classify the weights into actor and use case weights. As a result, the present study enables a UCP-based use case priority and SW effort estimation. The proposed method will be applied to renewable energy monitoring system development in future studies.

## 5. Acknowledgement

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