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Energy Management System Supporting Variable Demand for Digital Power Meters

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Abstract-For smart grid, demand response is important part. In this paper, we make energy management system supporting variable demand for digital electricity meters. This system consists of power detector, signal distributor, SMPS, load controller, and web-based management program. And we do check error rate between detected data and real data.

Keywords- *Digital Power Meter, Demand Control, Demand Response, Peak Power*

I. INTRODUCTION

By Reference [1], Information and Communication Technology (ICT) and advanced automation concepts provides various opportunities to operate highly interconnected power equipment in a more effective way, known under the term smart grid [2]–[4]. Specially, DR (Demand Response) management draws great attention in the electricity consumer side, such as [5]–[7].

In this paper, we design and implement CEMS (Clever Energy Management System) named by us, and this can support variable demand for digital power meter. We make all modules of the system such as power detector, signal distributor, load controller, and web-based control program.

This paper is organized as follows. Section II describes out our system architecture and modules in detail. Section III provides the two result of an error rate test. Section VI concludes the paper and provides an outline of future work

II. CEMS (CLEVER ENERGY MANAGEMENT SYSTEM)

A. System Architecture

Our main goal is making load controller supporting variable load for digital power meters. To do this, our system consists of upgraded signal distributer, power detector, load controller, and web-based management program.

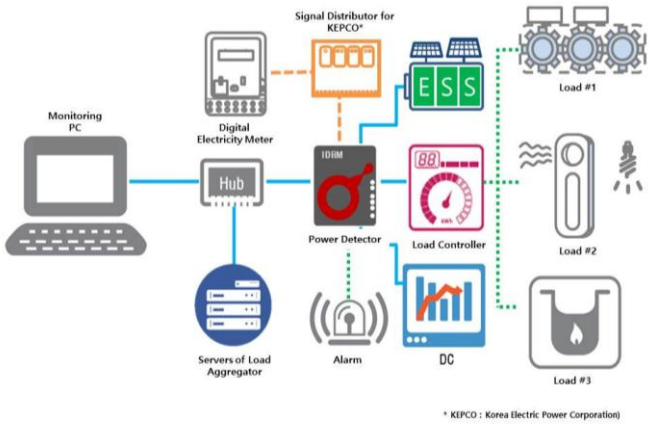


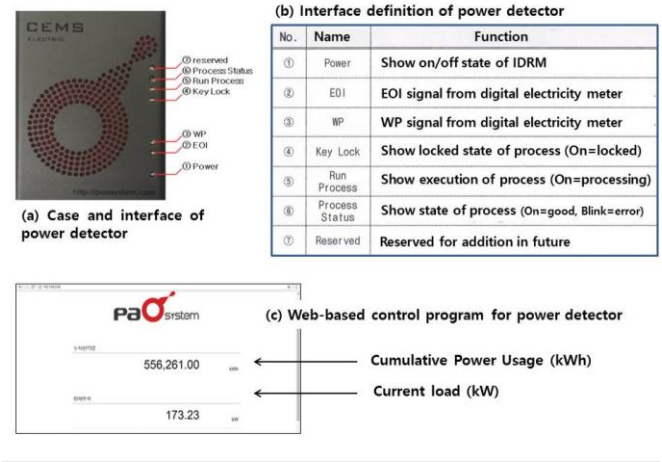
Figure 1. CEMS architecture

- Upgraded signal distributor: this device supports in/out metering signal distribution basically, and upgraded to handle both AC and DC using non-contact pulse gathering.
- Power detector: this device detects current forward active power and then computes target power from peak power requirements and active power according to variable loads.
- Load controller: this module usually monitors peak power and real-time active power, and controls load at power cutback time by load aggregators.
- Web-based management program: this program can show real-time demand monitoring, load power, usage analysis and searching results.

This system can manage variable power demands regardless of providers, and work with ESS (Energy Saving System).

B. Power Detecter

This module calculates integrating electrical energy using WP (Watt Pulse) signal and EOI (End of Interval) from digital meters of electricity customers.



No.	Name	Function
①	Power	Show on/off state of IDRM
②	EOI	EOI signal from digital electricity meter
③	WP	WP signal from digital electricity meter
④	Key Lock	Show locked state of process (On=locked)
⑤	Run Process	Show execution of process (On=processing)
⑥	Process Status	Show state of process (On=good, Blink=error)
⑦	Reserved	Reserved for addition in future

Figure 2. Power detector

- It can manage effective power usage and peak power using WP signal
- It can control demand time using EOI signal.
- Error detection: this detects no WP or EOP signal error over configured time, communication error.
- Web-based control program can monitor cumulative electricity energy and current load with additional S/W installation.

It can manage effective power usage and peak power using WP signal, and control demand time using EOI signal.

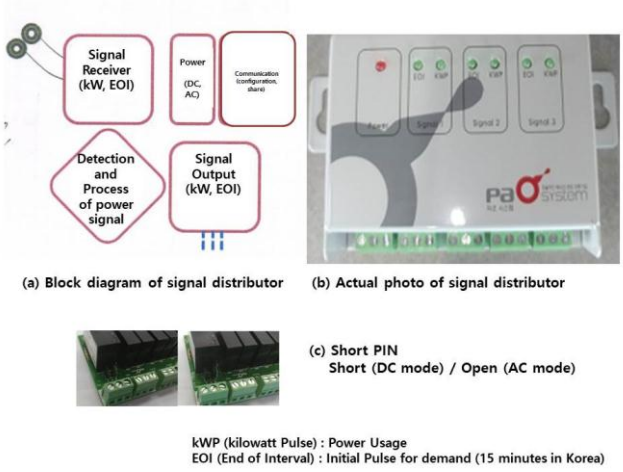


Figure 3. Signal distributor

C. Signal Distributor

This module distributes WP signal and EOP signal (default demand time = 15 min.) from digital KEPCO power meters.

This can do following functions:

- Support both AC mode and DC mode using short pins.
- Amplify and distribute signals according to the current detected from clamp-type current detector.
- Support current sensitivity control that other signal distributors cannot do.
- Detect error condition: this detects no WP or EOP signal error over configured time, communication error.
- Provide web-based control program can monitor cumulative electricity energy and current load with additional S/W installation.
- Reduce the electricity usage by managing peak power and power demand of electronical equipment efficiently.

D. Load Controller

This module controls load by changing analog input to digital signal using AD converter, and changing translated digital signal to analog output using DA converter.

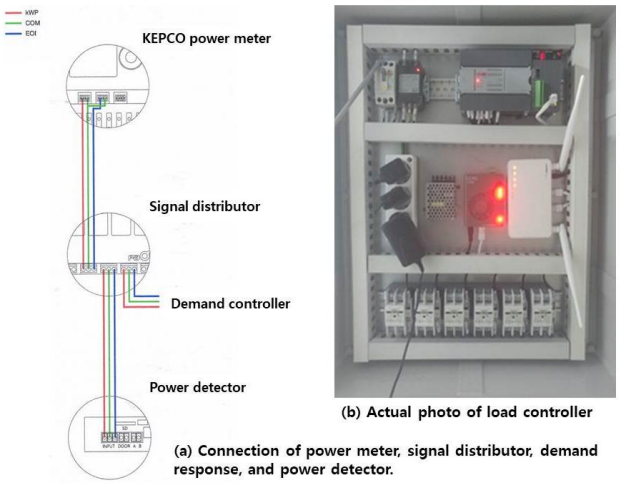


Figure 4. Load controller

This can do following functions:

- Control load using sequential voltage regulation at peak power.
- Easy to control inverter-based equipment, for example, Electric furnace, air conditioner, lighting and so on.

E. CEMS control program

CEMS control program is web-based control program, and consists of following contents.

TABLE I. CEMS FUCTIONS

Function	Details
Login	- Management of user accounts - Management of user rights (administrator, operator, reporter, and guest viewer)
Dashboard	- Goal per year and its achievement - Monthly goal and its achievement - Realtime usage of electricity, gas, and steam per day. - Usage ranking by equipment about electricity, gas, and steam
Real-time monitor	- Sorted by usage, share, and kind of energy (TOE/CO_2/TJ) - Current load at an interval of one minute. - Cumulative daily usage (0:00~23:59) - Cumulative monthly usage - Cumulative usage per year
Report	Show and can be exported as an EXCEL file
Data analysis	- Data per day/week/month/year - Searching during user-defined period - Minimum/average/maximum power load
Unit conversion	- The rate of achievement compared with an aim - Manage according to manufacturing number or equipment
Configuration	- User accout, converter, and atagories - Tariff (power/gas/water/steam)

The Dashboard page shows as below.

DEMS dashboard consists of 4 parts as showed in Fig. 6.

1) Goal usage per year and its achievement

- Total capacity from the first day of that year to now.
- Target usage, current usage and its ratio for electricity.
- Target usage, current usage and its ratio for gas
- Target usage, current usage and its ratio for steam

2) Goal usage per month and its achievement

- Total capacity from the first day of that month to now.
- Target usage, current usage and its ratio for electricity.
- Target usage, current usage and its ratio for gas
- Target usage, current usage and its ratio for steam

3) Real-time usage of electricity, gas, and steam

- Energy usage for each electricity, gas, and steam as a graph continuously.

4) Usage ranking by equipment

- Energy usage ranking (unit: kW) of equipment for each electricity, gas, and steam in descending order.

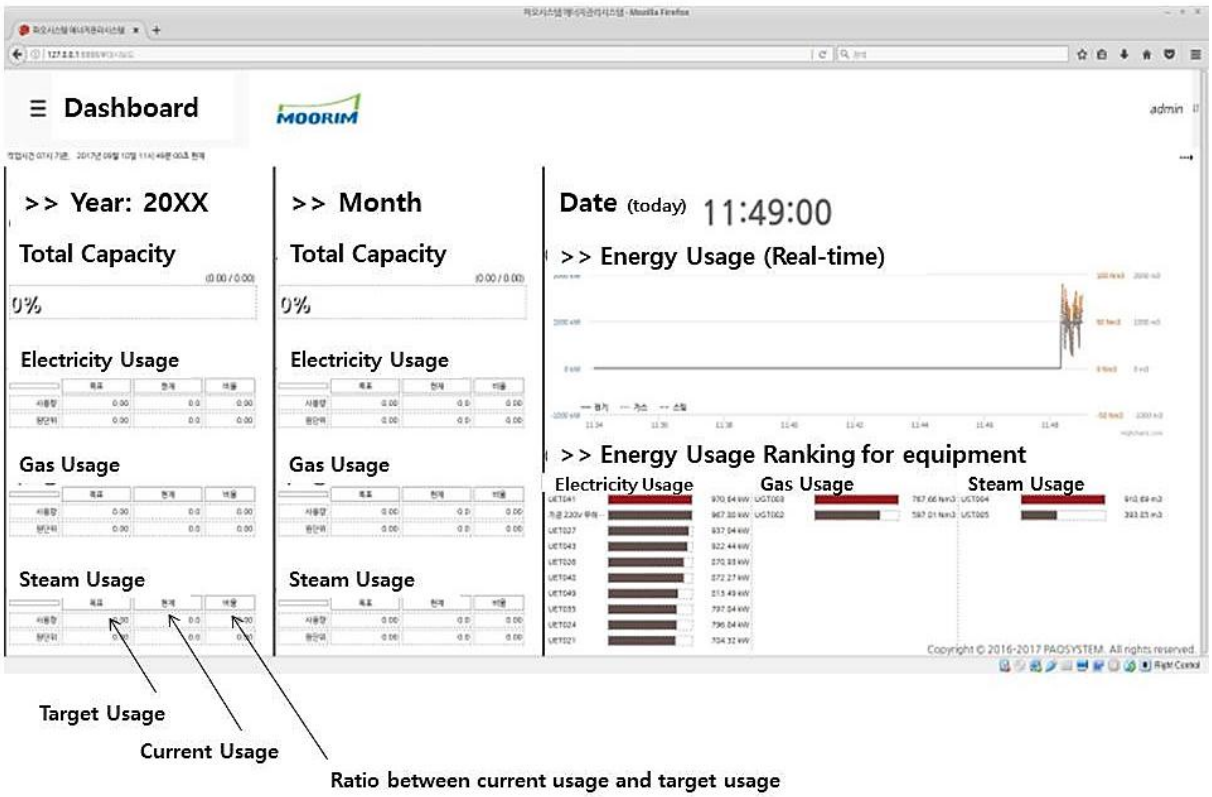


Figure 5. CEMS Dashboard

III. Error Rate Test for Power Data

This test is to verify error rate between the data of power detector and the data of KEPCO meter. Our goal was under 0.5%.

A. *Daehan Special Metal Co.*

Max. error rate is 0.31% and minimal error rate is -0.27%.

B. *Byuck-Jin Bio Tech Co.*

Max. error rate is 0.29%, and minimal error rate is -0.27%.

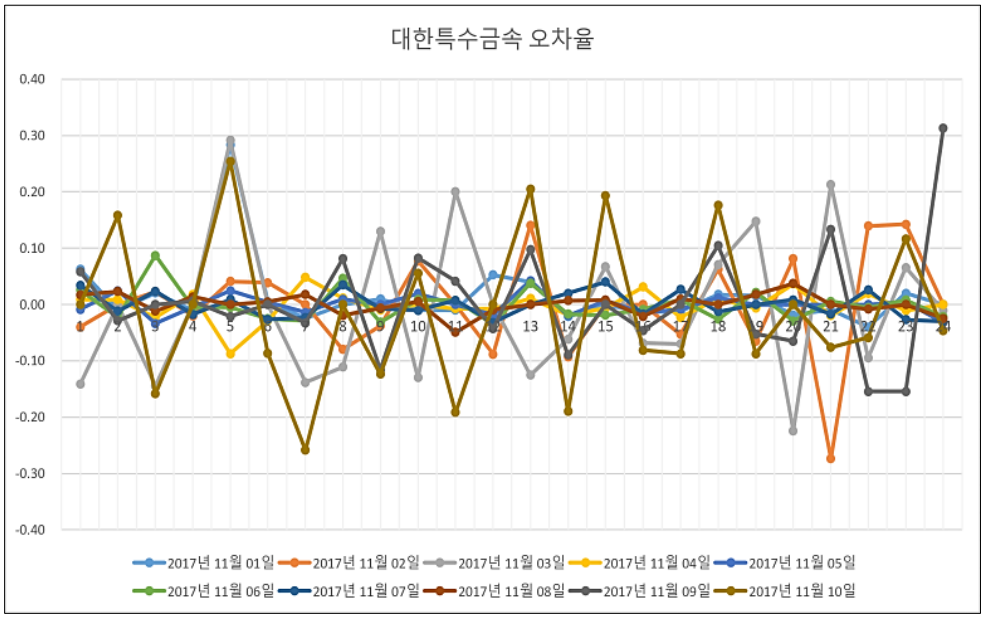


Figure 6. Error rate of Daehan Special Metal Co.

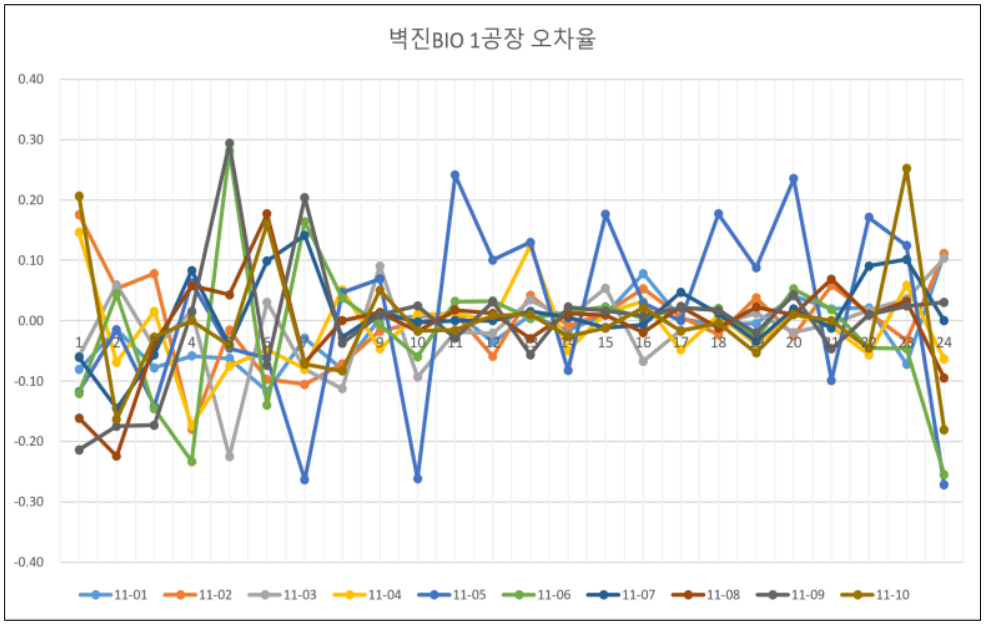


Figure 7. Error rate of Byuck-Jin Bio Tech Co.

IV. CONCLUSION

In this paper, we suggest the management system supporting variable demand for digital electricity meters. To verify our system, we do error rate test between our power detector and KEPCO power meter. As a result of the error rate test, we show our system can detect the power usage in real-time with low error rate. For further works, we extend our system for AMI (Advance Metering Infrastructure) and Smart Grid.

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