

Integration of resident's energy costs in short stay accommodation billing system

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Abstract— This paper presents an energy management software package and the supporting energy information automation system to enable the short stay accommodation industry to determine actual residents' energy consumption. The proposed energy management system is used to develop a 'novel deal' method in short stay accommodation based on integration of the room level energy costs into the billing system. This system has the potential to increase energy efficiency in the short stay accommodation industry by actively engaging the residents in the energy saving process. The system is economically and environmentally sustainable and can achieve a high level of energy efficiency with low expenses. The proposed model is also effective for carbon mitigation, and offers a value proposition for all the parties in the short stay accommodation industry, including owners and residents. The paper presents a software system to capture room level energy consumption information and to present the detail of consumed energy information in the resident's accommodation bill. The presented information includes energy consumption profile, the greenhouse gas emission profile, and the cost associated to the energy related services.

Index Terms-- Energy saving, Energy efficiency, Greenhouse gas emission, Short stay accommodation.

I. INTRODUCTION

The world has begun to observe the serious impact of climate change over the past three decades, along with increasing environmental pollution and extreme weather conditions. In addition to the large-scale industries that are commonly known as major polluters, small and medium enterprises (SMEs) such as the short stay accommodation industry are also among the environmental polluters, with 6 percent of the estimated total greenhouse gas emission worldwide [1, 2].

Within the short stay accommodation industry, which includes: hotels; motels; service apartments; caravan parks; student accommodation; and bed and breakfast, the residents do not own the accommodation and do not pay for the operating costs such as electricity, gas, water and other service costs. The energy efficiency subject has not received enough attention in the short stay accommodation SMEs, due to a limited of financial resource allocated in its business model [3]. Most of the short stay business owners do not have the energy efficiency information and are not aware of the energy saving guidelines. Previous technological systems employed in this industry were not economically sustainable and commonly have a pay off period of several years [4]. Currently, different technologies are used for energy management and saving for hotels [5-10], such as a very basic system to turn off air conditioning and lights when the guest leaves the room. However, none of these technologies can actively engage the guests in the energy saving process and therefore have no influence on the guests' energy consumption behavior. With this regard, there is also no specific low cost and high efficiency technology in existence that can be used for energy efficiency in short stay accommodation.

For industries and SMEs, environmental management systems (EMS) including ISO 14001 are considered a practical measure toward environmental sustainability [11, 12]. However, the suggestions provided by these standards can be costly and fail to be sustainable, by not engaging end-users in the energy saving process [4, 8, 10]. The existing studies in the literature regarding energy efficiency and energy saving for short stay accommodation can be categorized into: 1) statistical analysis of energy, water use and waste disposal for

different short stay accommodation industries [7, 13-18]; 2) new technologies for energy saving and energy efficiency for hotels [4-7, 10, 15, 19, 20]; and 3) various energy analyses in different hotels around the world [4, 6-10, 13, 17]. There is lack of low cost and specific technology for energy efficiency in short stay accommodation. Simmons et al. [10] described a central power unit system that could control the lighting and air conditioning based on the human occupancy, but it does not have any incentive for the residents to save energy. There are several studies on the guests' energy consumption [21, 22] where improving end-user's energy consumption behavior is a challenging task. In this paper, the authors have developed a novel method that can actively engage and encourage residents of short stay accommodation in the energy saving process. The method is promising in regards to being low cost, having high energy saving performance and providing economic and environmental sustainability for this industry [23, 24]. This paper presents a software package that has been developed for the proposed energy saving system for the short stay accommodation industry.

This paper is organized in five sections as follows. In Section 2, an overview of the typical energy consumption and the greenhouse gas emission by the short stay accommodation industry are given. Section 3 briefly introduces the Green Accommodation Deal model. Section 4 presents energy management software package that has been developed for the model. Finally, the discussion and concluding remarks are presented in Section 5 and 6 respectively.

II. ENERGY USE IN SHORT STAY ACCOMMODATION

A. Background

There exists previous studies for energy consumption in different hotels, in various places around the world, including: China [9]; Hong Kong [15]; Greece [6]; Germany and Estonia [8]; New Zealand [14]; North American [16]; and Turkey [25], where analysis of energy consumptions and reporting outcomes of energy efficiency for hotels were presented. For example in Australia, the Australian Bureau of Statistics (ABS) 2011 report [26] indicated that there are 4250 hotels, motels, guesthouses and service apartments with 15 or more rooms/units. The report shows that approximately 2128.8 million dollars coming from hospitality accommodation for the period April to June with 6.0 percent growth as compared to 2010. This survey was created from 226,582 rooms with 637,298 beds, and shows the average occupancy rate of 61.0 to 65.5 percent for the period from April to June of 2011. From the literature, hotels' energy cost varies between four to ten percent of business revenue. In this study the energy cost is assumed to be at an average of seven percent. This means that the annual energy cost of hotels in Australia is estimated to be \$596.1 million in 2011. The short stay accommodation SMEs have limited resources and currently struggle to survive the current climate change. There are increasing driving forces towards environmental compatibility of the hotels due to an increasing in the costs of energy and the introduction of energy efficiency policies, such as Carbon Tax. However, most of the technical ideas for energy saving in hotels are derived from other industries; therefore they are not optimized for this industry. The increasing price of energy has provided

an opportunity for researchers and entrepreneurs to develop specific and optimal energy efficiency methods and tools for this industry. Researchers have shown that by providing energy information to end users, it is possible to reduce energy consumption by more than twenty percent [27]. Knowing that, if our method could achieve twenty percent saving in the energy consumption in hotels, the method has a value of 119.2 million dollars per year only in Australia [24].

Researchers have investigated the concept of green buildings from different perspectives. Some look at the entire life cycle of hotels [16, 22, 28]. Other studies focuses on energy efficiency for public and governmental buildings, which are also useful for short stay accommodation buildings [7, 11, 13, 16, 19]. The importance of human energy consumption behavior has been noticed within the literature, but it remains a challenging issue, due to the complexity of the human's behavior. Some researchers have used information channels and educational materials to improve the energy consumption behavior [20, 27], however these methods are unable to provide a cost feedback to the residents.

B. Existing short stay accommodation deals model

The current model used in short stay accommodation deals is a fixed price model. In such model, the resident's costs are independent of the resident's amount of consumed energy. Such model is unable to address the energy consumption of the residents; therefore it could not provide any incentive to encourage the resident to be engaged in the energy saving process. Due to this reason, large-scale short stay accommodation commonly adopted high energy efficiency equipment to reduce their energy consumption. A study by Sloan et al. [8] have shown hotels that have used energy saving methods have experienced an increase in their market share and profitability, however this comes with a high level of investment and a long pay off period.

III. GREEN ACCOMMODATION DEALS

Miller et al. [22] have studied customers preference for selecting hotels; they have shown that 86% of the guest preferred the environmental friendly hotel than conventional hotel model. The authors of the current paper have introduced a "Green Hotel Deal" model in [24], in which the accommodation deal consists of a fixed value room expense and the cost of the actual consumed energy by the guest. This model requires a supporting technology infrastructure that will enable short stay accommodation to measure individual resident's energy consumption. It also needs to have an automation system to automatically collect and record energy consumption data. This information can be used to calculate the energy cost and integrate into the accommodation billing system.

There are two main components of resident's energy consumptions: electricity and water (hot water). If the accommodation has a central air conditioning system, then an additional energy component associated to the air conditioning will be involved. An automation system has been presented in [24] that includes: room sensors, an energy management system, a communication channel, and a software module. The sensors are used for metering electricity, water, and air

conditioning, the communication channel is used to collect data from the sensors. The software aims to integrate resident's energy consumption in the accommodation billing system. This idea is illustrated in Figure 1.

IV. ENERGY MANAGEMENT SOFTWARE

In order to introduce the green deal services into the existing and new hotel system, a hotel billing system that

incorporates the energy consumption has been developed.

Although the software has been designed to operate as a stand-alone application, the structures are modular that allows it to seamlessly work together with the existing hotel management system. An overview of the implemented architecture is illustrated in Figure 2.

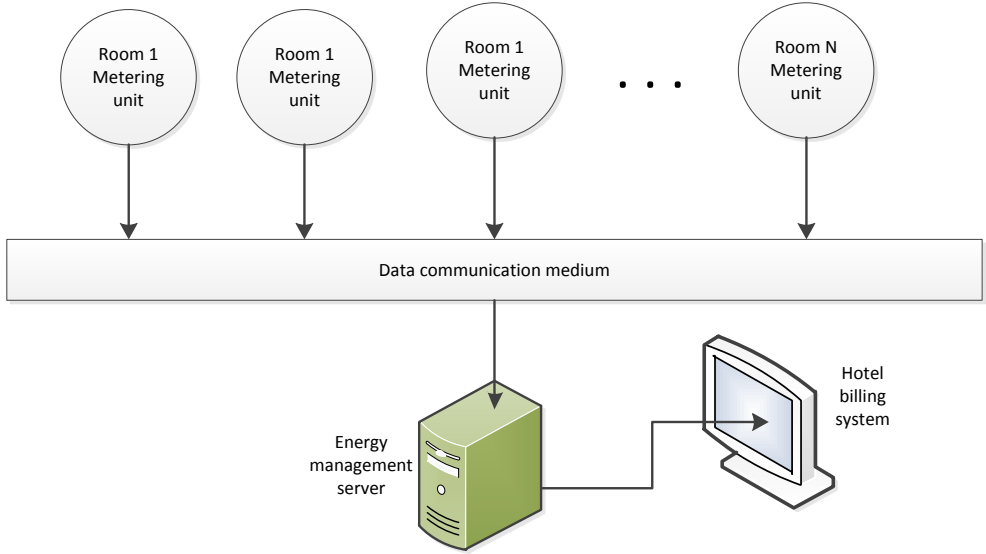


Figure 1- A schematic of green accommodation deals automation system

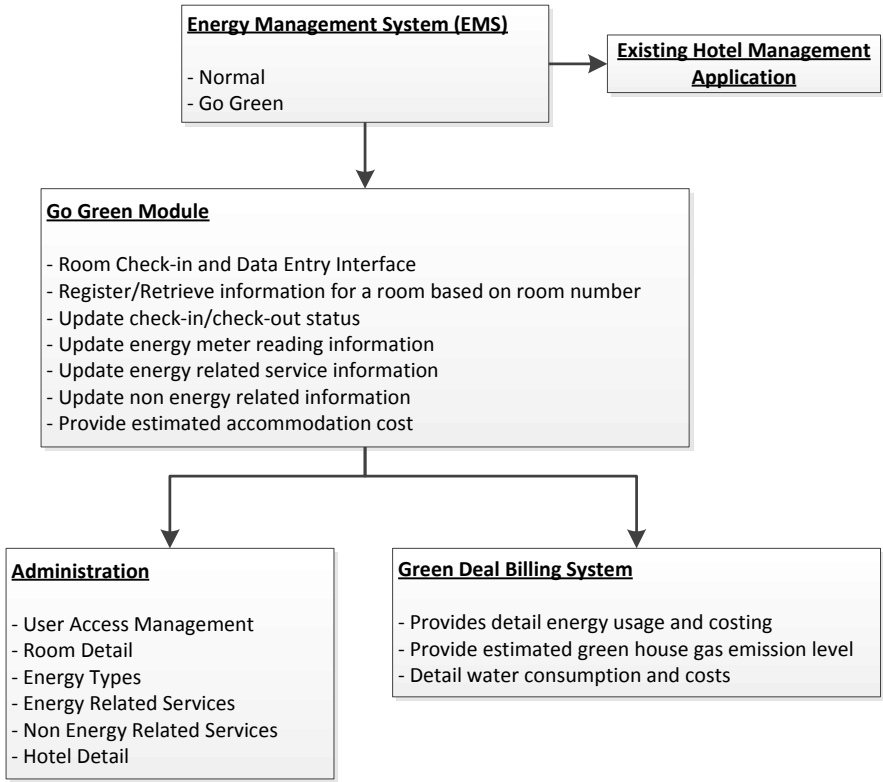


Figure 2- Three layered architecture for energy management system

This software model shows that the energy management software consists of three layers. The first layer shows the type of accommodation deal that should be applied for an arriving customer. The second layer is used for data entry. The third layer consists of two modules that operate independently. One module is responsible for administrative related tasks that are only accessible by the hotel manager, to defined detailed information regarding room, energy type, services and their related costs. The second module on the third layer is the detailed view billing module.

The green deal option database schema currently constructed using nine tables are demonstrated in a relationship diagram given in Figure 3. This is a relational database containing: energy information; energy related services; non-energy services; customer information; room information; administration access control and the other tables containing the base entry information.

The next two sub-sections provide an overview of the main software interface and billing system that has been implemented.

A. Hotel billing system and go green option

Energy management module is a software application that allows hotel to manage the costing of those customers who chooses to undergo a green deal option. At the time a guest arrives at the check-in counter, they will be presented with two accommodation options. The guest can choose either to go for the normal or the green deal option as illustrated in Figure 4. When hotel guest chooses the normal option, the system will use the existing hotel accommodation management software to manage all their costing fees and charges. If they decided to go ahead with the green deal option, the green management interface will be used to manage their accommodation fees and service expenditure. This green option interface is demonstrated in Figure 5.

The green deal system keeps a record of guest energy and water consumption through their accommodated period. These forms of energies are charged based on standard measures, such as cost per KWh and cost per litre, for electricity and water consumption level respectively. The consumption charges criteria are similar to the current billing system that applies throughout the Australian regions. At the moment the gas and other sources of energies are not taken into consideration, however it is possible for the user to define additional types of energy inside the software.

The green deal system has two modes of meter reading methodologies. The first method is carried out when the customer checks-in into a particular room, where the beginning meter reading is recorded that can be either manually or automatically executed. A final reading is performed at the time the customer checks-out. This first reading method only provides the total reading over the accommodated period. The information might not be sufficient if a customer requests a detailed overview of their consumption information. These concerns have been addressed in the software design stage, as the second meter recording method is taken into consideration. The second method samples the meters reading at a predetermined periods and records them into a text file. The software uses this data to provide higher detail of energy consumption information and present them to customers and hotel managers upon request.

When choosing the green deal option, the customer needs to be aware of the energy related services cost. Currently, the type of service considered includes, Room Cleaning, Washing Blanket, and Washing Towel. These activities will be recorded from time to time by the servicing staff member, when they are carrying out the task. The cost of these services will be charged in accordance to the number of times the task is performed over guests staying period. As the aims to working towards an environmentally sustainable future, a working together philosophy was employed.

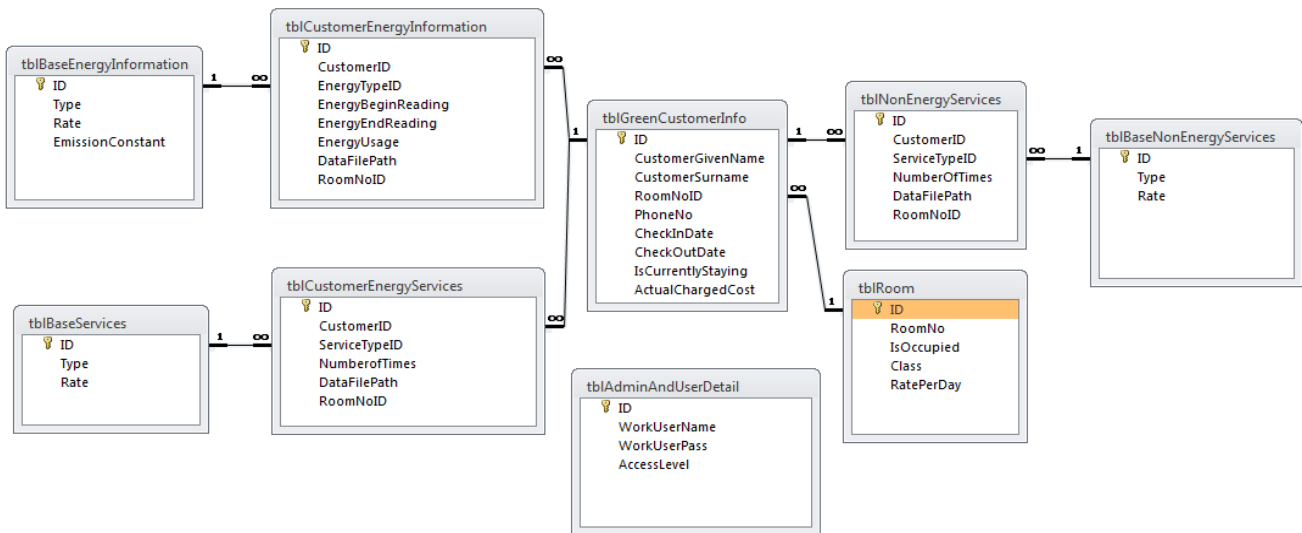


Figure 3- Energy management database structure

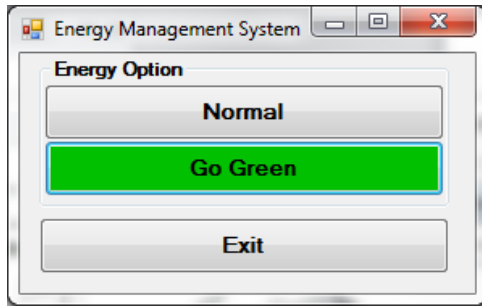


Figure 4- Green deal option

This working together concept promotes hotel guests to choose to limit the number of these activities on the daily basis. By doing just that, it would minimize the level of impact to the environment, while guests get rewards for their actions, as these contributing behaviors will reduce the greenhouse gas emission and can result to an overall reduction in their accommodation bill.

Apart from energy related services, the systems also keep track of the consumable service or other services that are similar to previous hotel accommodation system.

B. Integration of energy costs in the billing system

Once a guest proceeds with the check-out process, their final meter reading is made. The summary of energy usage and final accommodation costing summary is presented in the form of a bill, similar to a normal electricity or water bill in Australia as is illustrated in Figure 6. The bill provides an indication of how much electricity energy and volume of water is consumed during the accommodated period. It also shows the estimate greenhouse gas (GHG) emission level and the summary of energy and non-energy related services. There are two types of display formats in the billing interface. The first display format shows the average daily consumptions. The second reporting format provides a detail view of the actual meter reading at discrete time interval over the accommodated period.

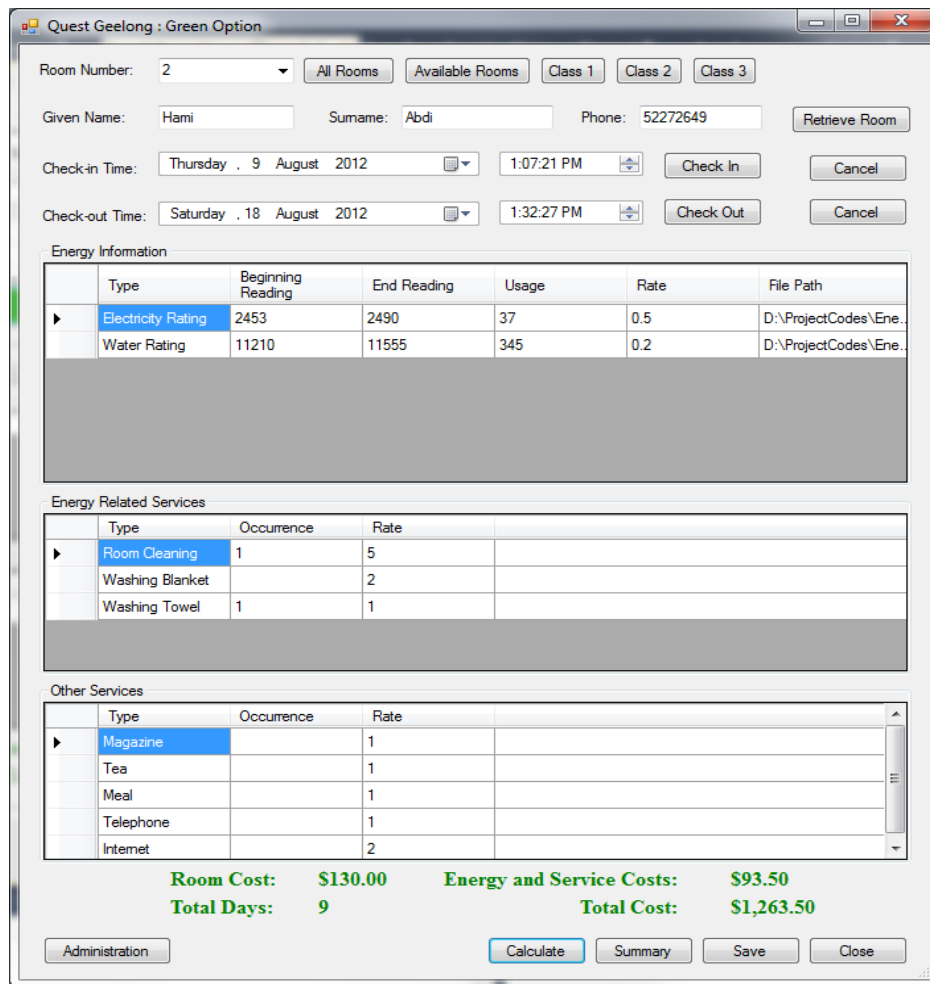


Figure 5- Green option hotel management system

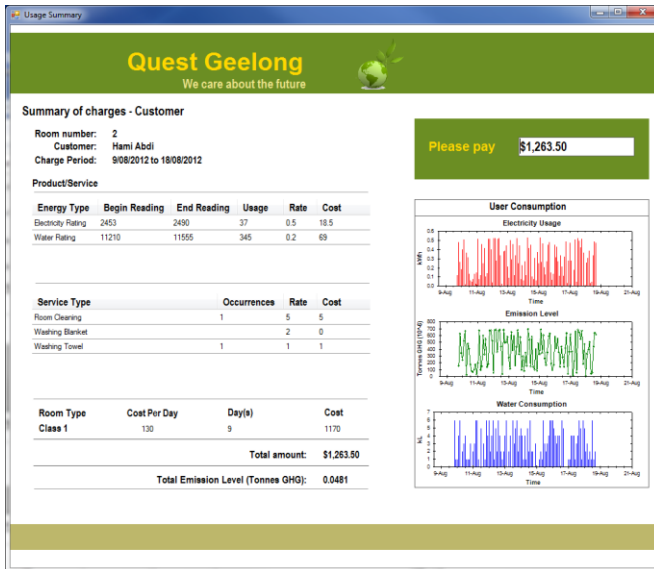
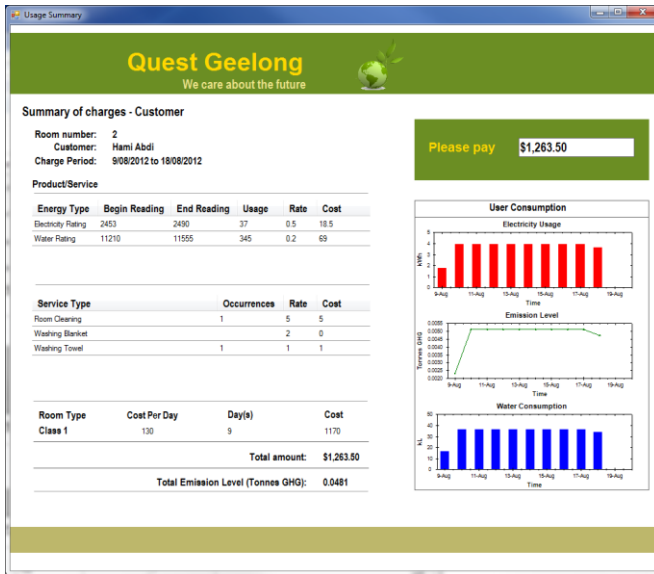


Figure 6- Green deal billing system, top) daily average format, bottom) discrete time meter reading display format

V. DISCUSSION

The proposed Green Accommodation Deals will provide several benefits to residents, business, and the environment.

For the residents: The green accommodation deal is cheaper than the existing deals as the extra energy costs are calculated from the actual resident's energy consumption. This method places the responsibility on the residents, which force them to be engaged in the energy saving process. The resident will promptly feel gratify of being in an environmental friendly hotel, as they are the one who actually doing something about the environment.

For the business: The green accommodation deal has the chance to gain higher market share due to residents' preference for environmental sustainable business. The

accommodation business will have lower energy consumption and lower energy bills.

For the environment: The green accommodation deals will contribute to environmental sustainability by reducing the energy consumption in short stay accommodation industry. This could result to a significant reduction of greenhouse gas emission if it is used by all short stay accommodation industries.

The only drawbacks on this idea are the cost associated to purchase the green accommodation deal technology and the market behavioral resistance. An economic sustainability analysis [24] has shown that the payback time of the investment and the cost associated to purchase the green accommodation deal technology is less than a year. This is much lower than any other technologies used for improving hotels energy efficiency. For the issues related to the market resistance, the proposed Green Accommodation Deal will be successful because all people will have cost incentive that could overcome. However, further research is required to clearly address this problem.

VI. CONCLUSIONS

Development of scientific and innovative methods for energy saving in small and medium short stay accommodation has the potential to help a large and distributed industry to improve their energy efficiency. Specifically there is lack of method to actively engage residents in the energy saving process. This paper presented an energy management software package and a supporting energy management automation system. This system will enable the short stay accommodation industry to determine actual room level residents' energy consumption and the related costs. The integration of the energy costs with the accommodation billing system was also shown in the software. The proposed system is economically and environmentally sustainable and can achieve higher energy efficiency with a low investment requirement. In the future, the authors aim to perform statistical analysis on the guest energy consumption and market behaviors based on the Green Accommodation Deals.

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