IntelligEnsia for Energy Sustainability

Case Study: Manado, Indonesia

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***Abstract*—Energy sustainability is one of the world focuses and a crucial matter today. In this information technology era, many fancy technologies have been designed and created to help human in creating the better living. In fact, they are also the main causes why the energy demand is increasing. This research is trying to introduce IntelligEnSia, as the recommendation in order to achieve the energy sustainability that focuses in Manado, Indonesia. We realize that the research in this field has been flourished, thus we want to introduce the competences of IntelligEnSia which are relied on the Business Intelligence and its potential to create the new effective behavior. It can provide intelligence reporting of the energy consumption for the better and effective energy management system in the city: resources, availability, consumption and characteristics peak load to peak off times. It is included the report of the list that have improved their consumption behavior. Finally, our solution may help government and industries in decision making and creating policies regarding energy management and the goal to achieve the new better behavior for the energy sustainability.**

Keywords— IntelligEnSia, Energy sustainability, Business Intelligence, Adaptive algorithm.

I. INTRODUCTION

In these recent years, energy sustainability becomes one of the world's focuses. It is also a crucial problem in Indonesia, especially in our city Manado. The needs of energy, its availability, utilization and optimization are the complex problems and even become ordinary matters to be faced by the society here. The government and some related institutions are certainly started to solve this, by looking for some new energy resources. The preferences are the renewable resources such as water, wind, sun, wave, geothermal, etc.

In other side, basically human need energy. The problem arises when the needs of energy are increasing. In this information technology era, many tools have been designed and created to help human in the better living. In fact, they are also the main causes why the energy demand is increasing. The results of fancy technologies such as PC, laptop, projector, modem, switch, router, smartphone, etc., are required energy consumption although in small amount. Since the production, selling and property of these modern tools are increasing; the energy consumption is increasing too. A simple example that having a smartphone maybe is a lifestyle. Most of the people do not care if using a smartphone may fulfill their necessary or just an ordinary hand phone is enough. We then may count that a person, once or twice in a day will re-charge the smartphone, laptop and LCD projector during the class.

Furthermore, to solve the problems above, human should use the energy efficiently and change the behavior. The success of changing the behavior is back to the environment and people them self. Creating the new behavior requires awareness from all elements. On the other side, we are focusing on the solution regarding the using energy efficiently. Here, we recommend an intelligent home system which is a system that may utilize and optimize the energy efficiently. Why intelligent home? Not intelligent office or some bigger areas? This is related with creating the new behavior. We realize that creating a new and effective behavior must start at home first. If people are used to with this behavior at home, then the implementation to bigger environments are easier.

We then recommend our solution which is called IntelligEnSia (Intelligent Home for Energy Sustainability). It will optimize an algorithm and build the software and hardware to implement the intelligent system that can manage the home energy consumption. It is called an intelligent system, since it is can control, learn and adapt the behavior of energy consumption in each house in order to give recommendation to the energy management in the city.

II. RESEARCH QUESTION AND OBJECTIVE

The research question here is focused on the question that is related to the energy's management and its efficiency. We then construct the research question as how to build a sustainable energy system for Manado area? And can it support the people in creating the new effective behavior? Thus, the objectives in this research are to build a sustainable energy system specifically for Manado area and creating the people new effective behavior.

III. STATE OF ARTS

A. Sustainability Science

The term sustainability has become frequently used nowadays. Sustainability Science has three main innovative characteristics: first, it addresses complexity with a trans-disciplinary approach. Second, it is problem-driven and it

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uses both scientific and local knowledge to resolve contextualized problems. Third, it promotes the active involvement of the different stakeholders, civil society, private sector and policy makers, in a process of scientific co-production. In line with the energy sustainability, it is necessary to have an integrated and trans-disciplinary approach for clarifying how to achieve a good legislation regarding the energy for mobility [1].

Based on an integrated and trans-disciplinary approach, Sustainability Science is oriented to study and understand the complexity of the interactions between economy, society and nature in order to propose concrete solutions to complex problems locally and globally threatening the very survival of humanity. Sustainability Science can help in creating methods and visions for analyzing the trade-offs and develops policy-making support tools to solve the concomitant risks to human well-being and security issues [2].

Sustainability Science is a new field that tries to understand the fundamental character of interactions between nature and society [3]. Such an understanding must include the interaction of global processes with the economical, political, ecological and social characteristics of particular places and sectors. The regional character of much of what Sustainability Science is trying to explain means that relevant research has to integrate the effects of key processes across the full range of scales from local to global. Combining different ways of knowing and learning, permits different social actors to work in concert. The role of sustainability science is also the distribution of knowledge to society through communication among experts, decision-makers, academics, politicians. The participation of diverse stakeholders in setting and implementing solutions is indispensable, because as science and technology advance, knowledge tends to be centralized; sustainability science tends to involve different expertise.

B. Energy Sustainability

The outline of Sustainability Energy definition proposed by the Sustainability of Energy Systems and Mobility Group, coordinated worldwide by Interuniversity Research Center on Sustainable Development (CIRPS), identifies five pillars for energy sustainability [4]:

• Renewability of energy resources;
• Efficiency in energy conversion, distribution, use;
• Lowering of environmental impact;
• Increasing of energy accessibility;
• Tailor making of energy systems to meet local social economic-environmental conditions.

C. Adaptive Algorithm

An adaptive algorithm is a set of instructions to perform a function that can adapt in the event of changes in environment or circumstances. Adaptive algorithms are able to intelligently adjust their activities in light of changing circumstances to achieve the best possible outcome. They can be programmed in a number of computing languages to do everything from automating air traffic control to returning search results that will be accurate and helpful for an Internet user. Regarding with this research, an Online Adaptive algorithm will be optimized in this application.

D. Business Intelligence (BI)

Currently, Business Intelligence (BI) has increasingly becomes more critical into the business operation. BI is concerned with the searching of company capability for a better understanding on its products and customers [5].
BI is a conceptual framework of decision support, which combines the architecture, data warehouses, analytical tools and application [6]. As suggested by Arrieta *et al*. [7], BI plays a big role in the strategic decision making. In the competitive environment, the business faces the following external uncertainties: Increasing customer demands, Enhancing role of the one-of-a-kind production and fast sequences of new tasks. The third one is the increasing number and speed of communication channels. The fourth and fifth are the appearance of new technologies and frequently changing partnership, suppliers, distributors, customers and purchasers. The last one is the instability of market circumstances. The external uncertainties can be answered by BI. As identified before, BI plays a big role in the strategic and operational decision making. The importance of BI is revealed as follow:

1. Corporate performance management.
2. Optimize the customer relations, monitor the business activity and decision support.
3. Support specific operations or strategies.
4. Management real-time reporting.

IV. Analysis and Discussion

We realize that for the sustainable energy matter, some solutions have been introduced and developed, such as Smart Grid technologies. The Smart Grid is "*a combination of hardware, management and reporting software, built atop an intelligent communications infrastructure. In the world of the Smart Grid, consumers and utility companies alike have tools to manage, monitor and respond to energy issues*" [8].

Smart Grid technologies are optimizing the asset utilization by shifting peak load to peak-off times [9]. Both Smart Grid and IntelligEnSia technologies are emphasized on the same core: optimizing the asset utilization, but IntelligEnSia then has the Business intelligence competence and potentially is effective to create the new behavior of the people for the sustainable energy.

A. Why IntelligEnSia?

- Control the energy consumption at home and buildings.
- Learn and adapt the behavior or characteristics of the energy consumption at home and buildings.

- Provide intelligence reporting of the energy consumption for the better and effective energy management system in the city: resources, availability, consumption and characteristics peak load to peak off times. It is included the report of the list that have improved their consumption behavior.
- Help government and industries in decision making and creating policies regarding energy.
- Create the new better behavior of the people for the energy sustainability.

B. *Case Study*

The following is the real example of consumption behavior in Manado. Figure below shows that in this common design house has 8 rooms, 10 points of lights and 7 points of wall outlets.

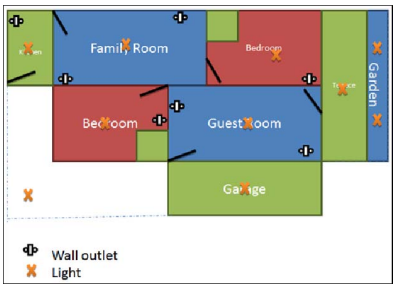

Figure 1. Simple house's layout

By using sensors, we can monitor and learn the characteristics of each category above. Furthermore, the software then can count the electricity consumption and manage when each category or even its member to switch on and off. We will then divide the rooms in 3 categories according to the consumption time:

- Group 1: All lights in the Living room, family room and bedroom. This group is using the energy dynamically and is the most inefficient since people are easily forget to turn off the energy.
- Group 2: All lights in the outdoor room: Garden, terrace and garage. This category is normally used only in the evening. Waste may happen if people forget to turn off.
- Group 3: All wall-outlets especially in the Kitchen. The consumption here is derived from the machines and tools such as washing machine, TV, Computer, etc, where people mostly are forget to unplug the electricity.

C. *IntelligEnSia Development*

In this case, there are two things we will develop:

1. From the electrical perspective, we will design a sensor and signal condition to retrieve the current (I), voltage (V) and power (P). The result then will be transmitted through Internet Protocol (IP) or other network with binary data format to a webserver to be recorded and analyzed.
2. From the software development, we will design and build an application that can monitor, record and analyze the energy consumption include the current (I), voltage (V) and power (P). The application is also will apply the *adaptive linear neuron algorithm* of the I, V and P parameters. Thus, this application then will be able to predict the electricity consumption of a house in a period. It is also provide a suggestion, for instance with the certain budget in a period, which part(s) must be used more efficiently. Furthermore, based on the business perspective and the software development, a business intelligence application that still integrated with the monitoring system will produce the reports. The reports are the outcome from the analysis and characteristics learning of the energy consumption of unique unit (machine/tool/light or outlet).

Thus basically, IntelligEnSia has 3 layers as displayed in the figure below: Device/physical, communication and application layers.

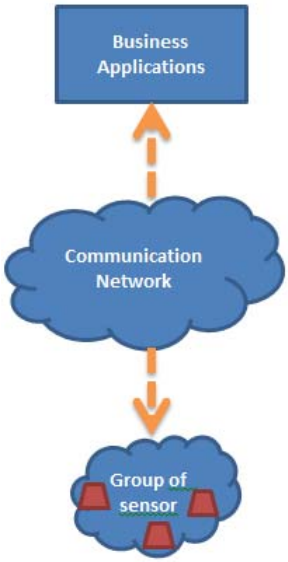

Figure 2. Device interacting with integrated Application

In terms of software development we optimize Agile method. Since it is emphasized on the importance of the people and interaction over processes and tools, working software and customer involvement toward changes, less detailed documentation is required [10].

D. *IntelligEnSia Mechanism*

The mechanism of IntelligEnSia as followed:

Firstly, the Sensor will read the condition of the light and wall-outlet, then the reading value of voltage (V) and Current (I) signal is forwarded to the analog digital converter (ADC). In ADC, the signal value is converted to discrete signal. The discrete signal then is processed by the microcontroller to be sent to the IP, where the signals before already formed in the digital data. Furthermore, the data is

sent to the webserver to be saved in database. The data then is processed to be the information that will give recommendation to the user in order to do some actions such as, turn off the light, unplug the electricity or give suggestion to be more efficient in using the energy. The following is the system block diagram of IntelligEnSia:

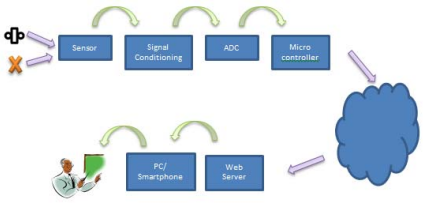

Figure 3. The System Block Diagram

E. IntelligEnSia Implementation

We have implemented the system block diagram mechanism. Based on our simulation, the sensor is able to read the condition of the light and wall-outlet. Then, the reading value of voltage (V) and Current (I) signal has been forwarded to the analog digital converter (ADC). In ADC, the signal value has been converted to discrete signal. The discrete signal then, is processed by the micro controller to be sent to the mobile application, where the signals before already formed in the digital data. The housing device (sensors), communication between housing device to mobile application and mobile Application in Android platform can run well.

First of all, customers can sketch and customize their house layout on the IntelligEnSia application as below.

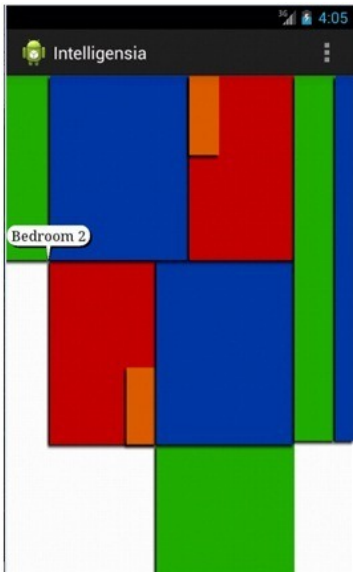

Figure 4. IntelligEnSia Mobile Application - layout

As displayed in the following figures below, through the application customer can monitor the consumption of each room on the chart.

Figure 5. IntelligEnSia Mobile Application – Room's report

The bedroom's Current and Voltage report.

Figure 6. IntelligEnSia Mobile Application – Room's report

The Mobile application can capture the information from the housing device (Sensors) and provide reporting behavior of the housing energy consumption.

V. CONCLUSIONS

IntelligEnSia can reach the goal of building a sustainable energy system for the case study. The result can control the energy consumption and help the local decision makers in creating better energy policies. It can also learn and adapt the behavior or characteristics of people in using the energy which may then create the new better behavior for the energy sustainability, since people can learn and recognise

their own behavior. Furthermore, the implementation of IntelligEnSia is futuristic because it may follow the future trends of technology such as mobile application and has anticipated the future needs. A feasibility study of IntelligEnSia's city pilot project is considered as a future work by involving the government, industries and society.

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