Internet of Things for Survey of Renewable Energy Potential (SREP) as the Basis for Hybrid Power Plant Development

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Abstract. In the future, microhybrid power plant for the household scale will be something that the people want. The obstacle that is faced by the developers in micro hybrid plant development is the lack of a preliminary study. If a preliminary study is not possible, at least the developer should conduct a potential survey to determine the place where the plant will be installed. Optimal position for the hybrid power plant can be obtained through a continuous mapping at some point during the season span. This study uses research and development procedures of the internet of things (*IoT*) for its purpose of survey of renewable energy potential. The aim of this study is to obtain the real time data of the potential of renewable energy with the help of the *IoT*. Internet of things which is developed using Airlink FXT009 EDGE is operated via serial communication. Modem Airlink FXT009 is controlled by ATmega328 microcontroller which received its data from the sensor network. The database which is processed by *IoT* consists of wind velocity, wind direction, output voltage, and stationidentity. The research shows that the average of wind velocity during April-September is 3.2 m/s and the output voltage is 13.3V.On the other hand, during October-March the wind velocity is 5.3m/s, and the average output voltage at 10:00-14:00 is 10.2V with the average of speed and data updates is per 75.34 seconds. This study is limited to the ATmega328 microcontroller as the processor and need to be developed towards a mini PC.*Keywords—internet of things (IoT), energy potential survey, hybrid power plant, ATMega328*

1 Background

Our concentration needs to be focus on the major threat to the depletion of fossil fuel reserves that the world is facing. Today most of the energy demand is met by fossil. A small portion met by renewable energy technologies such as wind, solar, biomass, geothermal etc. While the projected needs of energy production in Indonesia in 2016 is amounted 52.369Gw or 3,1Gw, increased from the previous year [1].

Energy needs in Indonesia is very dependent on geographical conditions. National Energy Councilspecifically states hybrid plants, the government policy is to develop a centralized PV to electrify many remote communities far from the grid in disadvantaged areas, the islands of the state border and the other outer islands. This was driven by the spirit of the government to provide access to electricity workforce faster to people in remote areas.

Hybrid power plants centralized location was chosen after considering the techno-economic factors such as the cost of transporting the fuel to the location. PV operatesas a hybrid with existing diesel, thereby reducing fuel consumption.

According to government policy, for optimal results in the development of hybrid power plants,potential mapped is needed. Survey of renewable energy potential continue to record the energy generated in one place. This mapping results determine the type of technology, location, transmission and this process needs to adapt information technology.Errors in the mapping causes the value of energy efficiency resulting smaller[2].

Internet of Things (IoT) is a development of field of applied informatics and proved in providing ease in solving the survey, monitoring and control device. Survey hybrid energy potential domestic scale is a matter that is necessary to determine the energy generated per month [3]. Control and related technologies will be essential to solve complex problems in the hybrid plants [4]. IoT provide more responsive and reliable services; a significant cost saving features can be developed based on the needs, accurate and real-time [5]. In simple words IoT will play a major role in energy saving [6].

This paper aims to describe the design ofIoTand explain the energy generated per month since December

2014 using IoT technology. Accurate data provides optimal results in selecting the location of the placedplant.

2 Theoretical Basis

2.1. Survey of Renewable Energy

Energy sources which can be replenished by nature and its supply isnot affected by the level of consumption is often referred to as a renewable energy. The need to find the renewable, alternative and non-polluting energy has become the top priority for the national energy supply autonomy. This requires the estimationof available energy resources accurately [7]. There are various ways to conduct survey of renewable energy such as; solar, wind, geothermal heat, ocean waves, biomass, etc.As for the wind power plants, as refers to equation 1, there are several things that need to be observed.

$$Power = 0.5 \times swept\ area \times air\ density \times velocity^3 \quad (1)$$

Since the air density is affected by the location while the speed is affected by the wind velocity, it makes these variables need to be observed. In addition, the wind direction needs to be observed in each period. Survey of solar power plant potential can be done by measuring the voltage which is generated in real-time within a month. The 100Wp monocrystalline solar panel is one of the instruments that can be used to measure the voltage because this panel has an output which is range between 0.1 up to 17.6 volts.

2.2. Web Service

Web services are a set of database applications, software or any part of the software that can be accessed remotely by various devices with certain intermediaries. In general, the web service can be identified by its URL just like other webs [8]. However, the feature that distinguishes web service from other websis the interaction provided by the web service. Unlike the URL of other webs, the URL of service web only contains a set of information, commands, configuration or syntax which is used for constructing certain functions of the application, as shown in Figure 1.

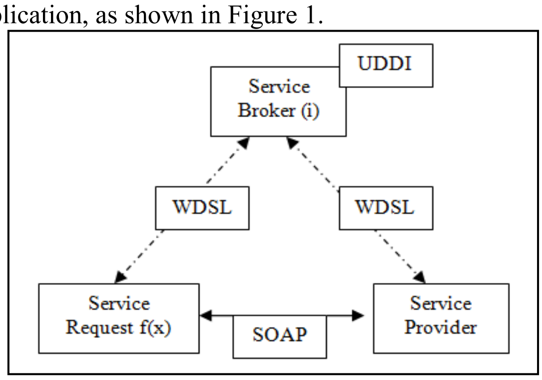

Figure1. Webservices architecture

According to Web services Architecture Working Group, the exact definition of Web service is a software system designed to support the interoperability machine-to-machine interaction over a network. Web service interfaces is described to be able using a format that can be processed by a machine (especially WSDL) [9]. Other systems that interact with the web service only requires SOAP, usually is written with HTTP and XML so that those systems have a correlation with the web standards.

2.3. Machine toMachine (M2M)

M2M terminology is derived from the term machine-to-machine, namely the integration of communication technology, computers and power which eventually enabling the long haul communication between machines [10]. M2M is a data computing application which is flowed to and from the physical interaction and biological process through sensors which are attached and processed by a microcontroller.

M2M refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type. Machine to machine is a broad term because it does not determine the specific wireless or wired network, information and communication technology. This broad term is mainly used by business executives. M2M is an integral part of the Internet of Things (IoT) and give benefits for the industry and business in general [11] because it has a wide range of applications such as industrial automation, logistics, Smart Grid, Smart City, health, defense, etc which is not only for monitoring but also for controlling purposes.

2.4. Internet of Things (IoT)

Internet of Things or IoT, is a concept that aims to extend the benefits of Internet connectivity which is constantly connected. The capabilities such as data sharing, remote control, and so on, as well as on the objects in the real world. Basically, IoT refers to objects which can be identified uniquely as virtual representations in an Internet-based structure [12].

Smart connectivity with the existing network is the basic context of the integral part of IoT. With the existence of wireless Internet, Wi-Fi and 4G-LTE, the opportunities of technology development will be faster [13]. Based on its concept, IoT consists of six main elements as shown in Figure 2.

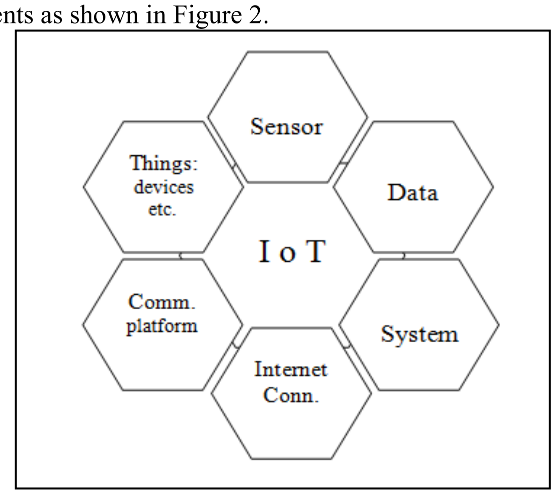

Figure 2. Part of the IoT

There are six IoT elements that emerge; sensors, devices, communication platform, internet connection, system, and data [14]. Computing paradigm will exceed the low-tech mobile computing scenarios and switch to Smartphone, portable gadgets and continue to develop into daily link. IoT refers to the identification of an object that is represented virtually in cyberspace or internet [15]. Thus, it can be said that IoT is how a real object communicated in cyberspace (internet) [16].

3 ResearchMethod

This IoT SREP research uses R&D procedure offered by Lee and Owens (2004) since it is a product-oriented research.It is divided into five phases; assessment/analysis, design, development, implementation, and evaluation phase [17].

3.1 Station Number

A total of 2 stations were implemented for this survey. The survey was conducted machine-to-machine due to limitations of sensor installed we surveyed. We would like to thank the engineers of PandansimoBantul Hybrid Power Plant and PUSDATEK (Center of Empowering Technology) Engineering Faculty, Yogyakarta State University in conducting this survey.

3.2 Location of Station

This survey was conducted in Bantul and Sleman District State, in the areas around Yogyakarta Special Region.Station 1 is locatedat coast Villages of Pandansimo, Srandakan, Bantul Regency and the station 2 is located atFaculty of Engineering, Yogyakarta State University, Sleman Regency. The distance between station 1 to station 2 about 43 km.

3.3 Classification of Station

Station 1 is located at the coastal area with the surface elevation of 3 meters above the sea level, on the ordinate of -7,9836423 and 110,2171283. Station 2 is located at an urban area with the surface elevation of 80 meters above the sea level, on the ordinate of -7,7717588 and 110,3867712. Both stations are given the same device and sensor, wind sensor WM30 and polycrystalline 100Wp, which are placed at the height of 15 meters from the ground. All the stations work in standalone for 24 hours with an independent supply.

3.4 Designing of IoT SREP

IoTSREP system development is supported by sub-fields of science that are continuous or mutually support each other i.e., mobile application, telemetry, web server, sensing, electrical and mechanical. The general overview of the system which will be developed in this research can be seen in Figure 3.

On the station area, wind speed sensor, anemometer sensor, and PV cell are installed to acquire the data of wind and solar conditions. These sensors will be installed as a standalone at selected locations, data will be sent through microcontroller ATmega328 based on asynchronous communication. The sensing results will be sent to server via EDGE-HTTP communication to data processing center. After that, the results of data reading in the field will be processed on the server, and displayed online so it can be accessed through the website monitoring or smartphone apps.

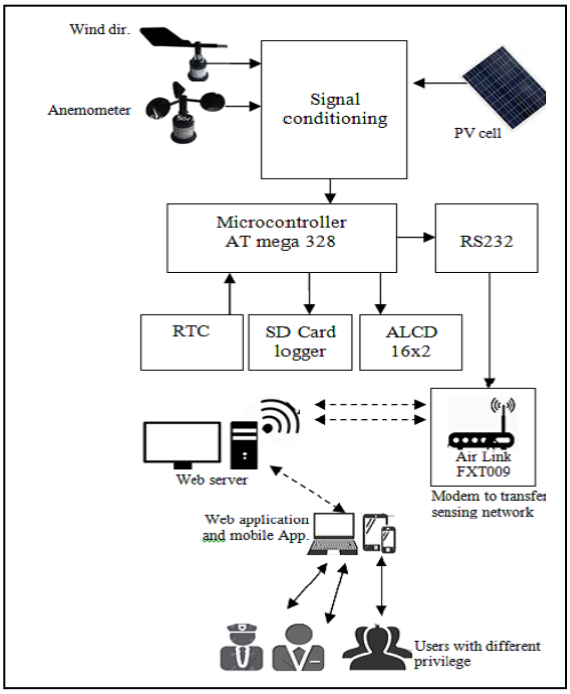

Figure 3. Working Mechanism of IoTSREP

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3.5 Coding (Hardware)

This paper only provides the script code for the hardware of sensors network, ATmega328 microcontrollerand device data logger. IDE used in this programming is Arduino programming language. To facilitate the understanding of the code, then the code is divided into blocks of programs that are numbered.

```
//[1]======prog utama===========
void loop() {
  proses();
}
//[2]======rutin proses=========
void proses(){
  val=analogRead(1);
  if(val<sens)
    stat=LOW;
  else
    stat=HIGH;
  digitalWrite(13,stat);
  if(stat2!=stat){
     conter++;stat2=stat;
   }
if(millis()-last>=milisekon){
doublerps=((double)conter/encoder)/16.0*1000/mil
isekon;
double
rpm=((double)conter/encoder)/16.0*60000/miliseko
n;
```

```
//[3]=====arah====================
nilaiArah = analogRead(0);
arah=(nilaiArah-144)/2.44;
delay(500);
//[4]=====teg PV==================
bat=analogRead(2);
double vbat =bat/204.8;
delay(500);
//[5]=============================
Serial.print("AT+WIPCFG=1\r\n");
delay(500);
Serial.print("AT+WIPBR=1,6\r\n");
delay(500);
Serial.print("AT+WIPBR=2,6,11,\"internet\"\r\n");
delay(1000);
Serial.print("AT+WIPBR=4,6,0\r\n");
delay(5000);
Serial.print("AT+WIPCREATE=5,1,\"pusdatek.ft.uny
.ac.id\",80,\"\",\"\"\r\n");
delay(5000);
Serial.print("AT+WIPFILE=5,1,1,\"http://pusdatek
.ft.uny.ac.id/telemetri/tambahdata.php?arah=");S
erial.print(arah);Serial.print("&kecepatan=");Se
rial.print(rpm);
Serial.print("&station=");Serial.print(station);
Serial.print("&vbat=");
Serial.print(vbat);
Serial.print("\"\r\n");
delay(1000);
Serial.println("AT+WIPCFG=0\r\n");
delay(1000);
//[6]====SD Card parsing data ke .csv=====
String dataKirim="";
int data1 = arah;
int data2 = rpm;
float data3 = vbat;
intdata[]=
{data1,data2,data3};
  int i;
for (int i =0; i < 6; i++){
    dataKirim += data[i];
        if (i < 5) {dataKirim += ",";}
    }
File dataFile =SD.open("datalog.csv",
FILE_WRITE);
     if (dataFile) {
     dataFile.println(dataKirim);
     dataFile.close();
     Serial.println(dataKirim);
     }
     else {
Serial.println("Tidakdapat membuka SDcard");
     }
```

The explanation of the code is given in the form of numbered blocks. Blocks number 1 till 2 are in the form of main program and routin program. The essential elements of the program is on number 5, commands sent via the AT+ Command extended. The process of transfer protocol over TCP socket is started from AT+ WIPCFG= 1 and ended with AT+ WIPCFG= 0. The codes for sensor network are on block number 2, 3, and 4 which are processed through the ADC, while for the process of data logger in the SD card is on number 6.

3.6 Implementation

The realization of IoT design, SREP, has been implemented at two stations in Bantul and Sleman. The results can be seen in http://pusdatek.ft.uny.ac.id/telemetri as shown in Figure 4.

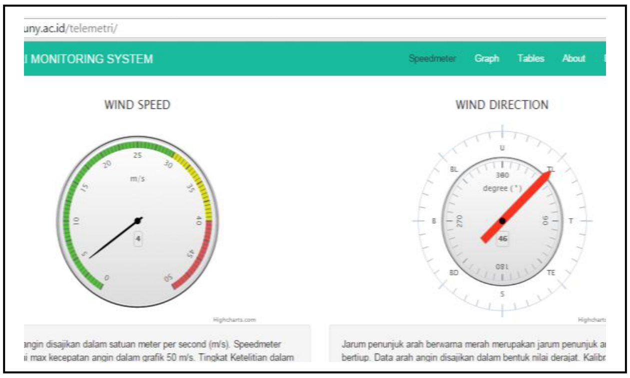

Figure 4.GUI of IoT SREP

There are three data display modes; gauge meter, polygon graphics, and tables. In the graphic, the data is presented in three different graphs for survey result of the wind velocity, direction and the results of PV output. As for graphics data, it is presented in a comprehensive manner.

Mobile application features (APK) are also available on the web in the download menu. Simple Viewer Telemetry application has yet to be available in PlayStore and AppStore. If you want to install this application, it can be done by downloaded this application in advance via website. The visualization results of APK IoT design applications, SREP, can be seen in Figure 5.

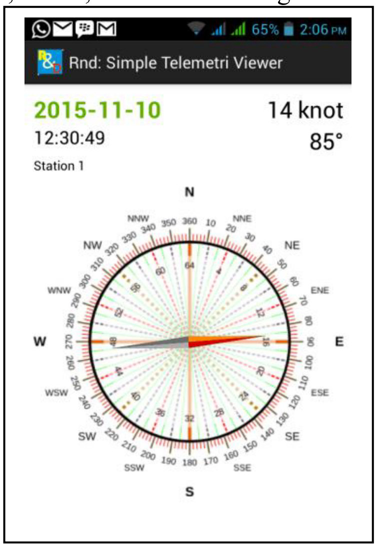

Figure 5.GUI Simple TelemetriViewerofIoT SREP

The schematic implementation from Figure 3, is designed as a compact using the ATmega328 in the minimum system.ATmega328 was selected since the chip has 32 KB of flash, 1KB EEPROM, 6 pin ADC and sufficient for the needs ofIoT SREP.

The key of the schematic realization into a hardware form,is clock 16 MHz and capacitor 22 pF as the resonator. Besides the selection of PCB materials is preferably using fiber materials.The empirical facts have shownthe neglect of those two things will cause asynchronous serial communication with baudrate of 115200 bps is disturbed. If it happens, then there will be an interference and the data received will be damaged/

corrupt. The realization of IoT SREPhardware is shown in Figure 6.

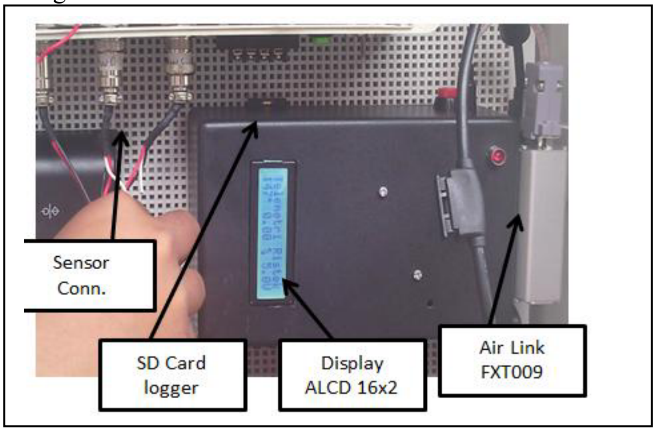

Figure 6. Main module of IoT SREP hardware

Figure 6 shows that the IoT hardware, SREP, is composed of SD card logger, ALCD 16x2 display, sensor networks, and modems AirLink FXT009. The device is packed in a waterproof box and can withstand direct sunlight. The outer part of the box should not be made of metal to reduce signal attenuation.

4 Result and Discussion

4.1 Result

The survey data of renewable energy potential using IoT, SREP is presented on the website in the form of tables, graphs polygon, and gauge meters. The data is displayed with the fastest updated time capture for every 76 seconds, with a capacity data transmission of 27 bytes.

Table 1. Survey Results of Renewable through IoT SREP[2]

Month	Wind speed (m/s)	Wind dir. (degree)	PV output (volt)
December, 2014	6.1	160	9.2
January, 2015	6.2	174	9.9
February, 2015	5.3	183	11.4
March, 2015	4.5	190	11.6
April, 2015	3.8	220	11.2
May, 2015	3.6	298	13.2
June, 2015	2.9	310	14.4
July, 2015	2.5	355	14.1
August, 2015	3.0	35	13.4
September, 2015	3.3	69	13.5
October, 2015	4.4	132	10.4
November, 2015	5.2	157	9.6
Ave. Apr. – Sept.	3.2	-	13.3
Ave. Oct. –Mar.	5.3	-	10.2

[2]data record during 10.00-14.00 (GMT+7)

IoT SREPdeveloped using EDGE FXT009 Airlink has been able to survey the potential of renewable energy.The research shows that the average of wind velocity during April-September is 3.2m/s, and the output voltage is 13.3V.On the other hand, during October-March the wind velocity is 5.3m/sand the average output voltage at 10:00-14:00 (GMT+07:00) is 10.2V with the average of speed and data updates is per 75.34 seconds. This research presents data managed as in Table 1. The decision on the construction of a hybrid power plant can pay attention to the findings of the above data.

4.2 Discussion

This study is limited to the ATmega328 microcontroller as the processor and need to be developed towards a mini PC.In addition, based on data and many stations the opportunity to specify the type of turbine, PV, and the system becomes more efficient.

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