A practical way to analyze Wind Turbine data: Wind Power Data Reader

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Abstract: To meet the growing demand, new ways are being sought to find new alternative sources. But, finding an alternate source is not enough, due to the fact that the power source should be sustainable and feasible. To be able decide whether it is efficient or not, we need to be able to analyze production rate. That is why data monitoring is an important area for energy production. We are able to gather raw data from power generator infrastructures. But these data is only raw data. We need a visual and interpretable ways to analyze, to utilize and to predict the efficiency of production. This paper focused on data monitoring part of energy production which output by wind turbines. The main purpose of this work is to provide to convert raw data into more readable and more analyzable format. We have prepared Wind Data Analyzer to visualize data by using elasticity of OOP (object oriented programing) to wind turbine data.

Keywords: smart grid, renewable energy, data analyzer

1. INTRODUCTION

The need to renew electricity networks is based on the growing electricity demand, the establishment of the electricity markets and the integration of more sustainable generation resources including renewable ones. This need forced scientists to build a new and efficient control mechanism for power grids named Smart Grid. Smart grid, a mechanism to provide bidirectional communication and control between electricity providers and consumers, is the subject of great public interest as...
a means to enable a more efficient and renewably powered electricity grid infrastructure (J. April 2010).

Having more information and control provides powerful capabilities; like providing more precise system design and performance, more reliability, capability to meet costumer need, more products and services, reduced environmental impact (Figure 1).

The existing technologies are combined with innovative solutions by Smart Grids network. Not only future grids build on existing one but also are led new system concepts to be implemented like “Wide area monitoring and protection“, “micro grids” and “Virtual power generation”. Centralized generation will stay as an important part of generation. But, many more actors will be involved in the generation, transmission, distribution and operation of the system including end customer. Based on these assumptions, we need to have rapidly deployable and cost effective technical solutions to enable existing grid to accept power inputs from other power sources without exceeding critical operation limit. There must be standards for equipment and protocols, so that different manufacturers’ equipment will fit together or one manufacturer’s equipment will be switchable with another’s one, and there must be a backward compatibility. Beside these, we need to develop systems of information, telecommunication and computing which enable utilization of innovative service arrangement to improve their efficiency (Buchholz 2006). Smart Grid network consist of following components; broadband over power lines, monitors and smart relays at substations, monitors at transformer circuit breakers and reclosers and bi-directional meters with two way communications.

As new alternative power sources are found, new supplies will be added to the grid systems. But, problem with alternative power sources is intermittent behavior (Yang Peihong 2012). It is not easy to integrate such power source to traditional power grid. With changing conditions, production rate changes. So it is necessary to utilize the energy before use or to transmit to power grid system(Ahmed Mohamed 2012). Wind power cannot be used as seldom power source. It must be backed up with other power sources such as hydroelectric and coal plants(Lovins 2011). This is also force us to utilize production and the backup system. To achieve a good utilization we have to interpret data carefully, otherwise it may jeopardize grid system or turbine safety. Taking the data which is gathered from wind turbines into account, it is really not easy to interpret data with thousands of lines as it is shown.
in Table 1. So it is necessary to visualize the available data. This will help us to interpret and predict how the power production will occur in a certain time range. This paper is focused on monitoring and analyzing data obtained from wind turbines. Functionalities and codes of Wind Data analyzer software will be explained in the paper.

Figure 1. Representation of Smart grid model
Table 1. Wind turbine sample data provided by http://data.aprsworld.com/

<table>
<thead>
<tr>
<th>Time</th>
<th>AC Voltage</th>
<th>DC Current</th>
<th>DC Voltage</th>
<th>AC Frequency</th>
<th>Output</th>
<th>Energy Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00:03</td>
<td>381</td>
<td>214</td>
<td>16</td>
<td>92</td>
<td>60</td>
<td>1402</td>
</tr>
<tr>
<td>00:00:13</td>
<td>374</td>
<td>214</td>
<td>14</td>
<td>83</td>
<td>60</td>
<td>1092</td>
</tr>
<tr>
<td>00:00:23</td>
<td>386</td>
<td>213</td>
<td>20</td>
<td>102</td>
<td>60</td>
<td>1908</td>
</tr>
<tr>
<td>00:00:33</td>
<td>423</td>
<td>216</td>
<td>48</td>
<td>156</td>
<td>60</td>
<td>7449</td>
</tr>
<tr>
<td>00:00:43</td>
<td>406</td>
<td>216</td>
<td>36</td>
<td>133</td>
<td>60</td>
<td>5105</td>
</tr>
<tr>
<td>00:00:53</td>
<td>415</td>
<td>216</td>
<td>41</td>
<td>143</td>
<td>60</td>
<td>6020</td>
</tr>
<tr>
<td>00:01:02</td>
<td>389</td>
<td>215</td>
<td>22</td>
<td>104</td>
<td>60</td>
<td>2434</td>
</tr>
<tr>
<td>00:01:12</td>
<td>397</td>
<td>215</td>
<td>26</td>
<td>117</td>
<td>60</td>
<td>2876</td>
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<tr>
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<td>396</td>
<td>215</td>
<td>25</td>
<td>116</td>
<td>60</td>
<td>2736</td>
</tr>
<tr>
<td>00:01:32</td>
<td>393</td>
<td>215</td>
<td>24</td>
<td>112</td>
<td>60</td>
<td>2765</td>
</tr>
<tr>
<td>00:01:42</td>
<td>384</td>
<td>215</td>
<td>20</td>
<td>97</td>
<td>60</td>
<td>1946</td>
</tr>
</tbody>
</table>

2. WIND POWER DATA ANALYZER

Wind Power data analyzer software is designed to analyze and visualize data which provided by http://data.aprsworld.com/ on daily bases. We are able to get lots of raw data from wind turbines. But, this data is only numbers or logs about current state of turbines. To say how efficiently this turbine functioning, we need to convert this data more readable format. So that was the reason that forced us to design wind data Analyzer. This graphical representation of raw data enables us to make more accurate prediction about performance and efficiency of wind power production. Some unique features are explained below.

- Interface design of wind data analyzer has a simple and all-in-one place design helps us to see everything in one place, but, tabbed design prevents confusion.
- Instead of using third party libraries, Wind data analyzer design with standard libraries. This fact helps us to save some budget and also mitigate portability issues(Jonge 2009).
With wind data analyzer, you can limit time range, so that summary will be shown for that range only. Beside this, zooming for selected area is available, this is to enable user to be able to examine a time range more closely.

You can get online data by selecting date and time range, if you have internet connection.

Figure 2. A sample view form wind data analyzer software

3. BACKGROUND OF WİND DATA ANALYZER: GATHERİNG DATA AND VİSUALİZİNG PROGRESS

Our software works with data provided by http://data.aprsworld.com/, and main features of it expressed above. In this part, we will focus on coding part and mention important points. This software designed by using C# programming language with standard libraries. We can group the functionality of software in to two parts.

3.1 Gathering online and offline data

Fetching process can be handled in two ways; the first one is getting online data. The technique which we used to gather data is URL generation. We generate URL by providing date, beginning and ending hours (Code Fragment 1). Webclient
library set connection to open related website with providing generated URL. After connection set, we fetch data by using StreamReader library.

```csharp
WebClient client = new WebClient();
client.Headers.Add("user-agent", "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.2; .NET CLR 1.0.3705;)");
string url = "http://data.aprsworld.com/data/ps2/rawData.php?station_id=A2671&packet_date=" + datadate + " 00:00:00&hours_before=" + starthour + "&hours_after=" + stophour;
Stream data = client.OpenRead(url);
StreamReader reader = new StreamReader(data);
onlineData = reader.ReadToEnd();
```

**Code Fragment 1.** Gathering online data

For the offline data, we download the same data for a date or dates from website with links provided by the site. The read data in to the software with

```csharp
if (openFileDialog1.ShowDialog() == DialogResult.OK)
{
    if (openFileDialog1.FileName != "")
    {
        richTextBox1.LoadFile(openFileDialog1.FileName, RichTextBoxStreamType.PlainText);
        data.AddRange(richTextBox1.Lines);
        data.RemoveAt(0);
    }
}
```

**Code Fragment 2.** Opening an offline file

### 3.2 Visualizing process

After fetching data, each line of data passed to an instance of Variable object then to a generic list structure (Code fragment 3). Instead of using static Array structure, we preferred dynamic data structure. This saves us from making assumption about the array size of thousands of lines. By this way, we make data available for the entire codes in our program.
List<Variables> dList = new List<Variables>();

            foreach (string s in data)
            {
                string[] sLine = s.Split(' ');
                if (sLine.Length > 7)
                {
                    variables var1 = new Variables();
                    var1.BusVoltage = int.Parse(sLine[5]);
                    var1.AcVoltage = int.Parse(sLine[7]);
                    var1.DcCurrent = int.Parse(sLine[8]);
                    var1.DcVoltage = int.Parse(sLine[9]);
                    dList.Add(var1);
                }
            }

**Code Fragment 3.** Reading data into generic list structure

To visualize data, instead of using a third party tool, we used ms charting tool to provide more portability. Using third party tool sometimes causes incompatibility issues.

Our program keeps each part of data in a separate chart on tab control to able to see everything in one place.

```csharp
            chDC.Series.Add("DC Voltage");
            chDC.Series["DC Voltage"].SetDefault(true);
            chDC.Series["DC Voltage"].Enabled = true;
            chDC.Series["DC Voltage"].ChartType = SeriesChartType.FastLine;
            chDC.Series["DC Voltage"].Color = Color.Red;
            chDC.Visible = true;
            foreach (Variables v in dList)
            {
                chDC.Series["DC Voltage"].Points.AddXY(v.Saat, v.DcVoltage);
            }
```

**Code fragment 4.** A sample code from charting tool

4. CONCLUSION

This work showed us that converting raw data to an analyzable format is vital. Due to fact that wind power systems (and also other alternate sources) are not completely independent from other systems. It still relys on other annual wind regime, backing up systems, power grid system. These dependencies forces us to make a good prediction, forecasting and installation planning. To be able to do all of these, we need more readable and analyzable data more than a data in raw format. As a next
step to our work, live data can be fetched and used for controlling wind turbines and the integration to smart grid systems.

REFERENCES