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Algona Municipal Utilities Power System Designs

DESIGN DOCUMENT

Contents

1 Introduction

1.1 Project statement

This project is based on the distribution system of Algona Municipal Utilities. The distribution system starts with the substation that is fed one or more subs transmission lines. (1) That means distribution system carries electricity from the substation to consumers. In our project, Algona Municipal Utilities hope to improve the old and weak overhead distribution system of Industrial company. Our goals is to build a high flexible, high reliability, and low cost new distribution system for industrial company.

1.2 Purpose

The most important part of power engineering is the experience of customers. So the satisfaction of target customer drives our project. On the same time, we need to meet the financial and technology problem of Algona Municipal Utilities. The distribution system ensures the life of people and development of world. Our project can help Utilities Company to save resources and support a better power distribution system for customer.

1.3 Goals

We would build a WindMil model that satisfy the all requirements of Algona Municipal Utilities. The main goals for this project is to complete:

- Build a high reliable and high flexible for target company based on the real situation.
- Build a low cost route for Algona Municipal Utilities.

2 Deliverables

1. We will find all possible routes with company requireS and choose two or three high reliable routes.

2. Build the simulation of distribution system with WindMil for every route.

3. Calculate the reliability index of every route.

4. Analysis the cost and calculate the payback time for every route.

3 Design

3.1 SYSTEM SPECIFICATIONS

System Specifications:

Simulation: WindMil by Milsoft

Database: DGR Engineering, Algona Municipal Utilities

3.1.1 Non-functional

Our design must meet the following non-functional requirements.

1. For the flexible problem, our design should have a higher electric capacity rather than the demand of industrial company. And we also consider the future expand of Industrial company to design our electric quantity.
2. For the reliability problem, different substation should necessary to guarantee primary reliability in a distribution system. SAIFI (System Average Interruption Frequency Index), SAIDI (System Average Interruption Duration Index), and CAIDI (Customer Average Interruption Duration Index) will be compared with IEEE 493-1997 to evaluation the reliability of design.
3. For the small cost problem, we combine the annual revenue of client and cost of our design to evaluation the influence of our plan. We need to consider the annual inflation ratio and interest ratio in 2017. And based the requirement of client, we will try to find the forecast about annual inflation ratio and interest ratio. We will use annual inflation ratio and interest ratio to calculate the payback period. The payback period shows the how many years client can obtain net income in our design.

3.1.2 Functional

Our design must meet the following functional requirements.

1. Test the WindMil model successful, use Fault current analysis and Voltage drop analysis to test.
2. The design route satisfies all specific requirement of Algona Municipal Utilities, like avoid the pole between feeder 1, feeder 2, and EB5. The reason is the current feeders are old wire, small capacitor, some minor tree and accessibility issues.
3. Finish the reliability index for every feeder.
4. Finish the cost calculation and payback period for every design route .

3.2 PROPOSED DESIGN/METHOD

Our design goal finds the best route for improve the power distribution system of Industrial company . And our proposed design idea meet the following step.

1.Draw the draft route with the requirements

2. Set up the load mix model for every segment

3. Set up the load zone model for every segment

4. Import the element data in WindMil circuit

5. Build the position of new sub-transformer

6. Test the design route and verify the customer voltage in the standard range

7. Calculation the reliability index

8. Calculation the payback time with reliability index, interest rate, fixed cost, variable cost, and annual inflation rate

3.3 DESIGN ANALYSIS

We calculated and draw the monthly peak demand figure to analysis the demand of Industrial company. Monthly peak demand is helpful when we expect the future demand of Industrial company. Monthly peak demand figure 1 and figure 2 show in the Appendices.

And we find all possible routes with currently requires. Now, we have 3 possible plans. There are a lot of real issues to limited the design, like railway, field, forest, etc. Based on the answer of client, we would like to avoid the farmland and railroad route that follows the current EB5 route.

We will set up a new sub-transformer to avoid the weak area. The position of new transformer shows in the Figure 4. We don't have the exact coordinate point of new transformer because the expansion of Industrial company just is a concept now. We will choose roughly position in our simulation and calculation.

The reliability of design should be important for us. We need to calculate the frequency of interruptions and average duration of interruptions for every element. Based on the data of every element, we can get the reliability data of whole system. The similar radial figure 3 shows in Appendix. (Chowdhury, Ali., and Don. Koval, 2011)

For our design result, we also need to think about the fixed cost inflation rate, labor cost, and others. We find the interest rate and inflation rate in 2017 in US. Also from the history of inflation rate between 2008 and 2017 and professional forecast for future inflation rate and interest rate, we calculate the total cost and payback time for client.

4 Testing/Development

4.1 INTERFACE SPECIFICATIONS

Software: WindMil

The Milsoft provides more than a thousand utilities. As a professional and widely used software, the WindMil circuit model is easy to implement for Algona Municipal Utilities.

4.2 HARDWARE/SOFTWARE

Fault current analysis test operational situations, such as determining whether equipment operating and capacity ratings are met. To ensure that the fault conditions will be interrupted by protection devices before unnecessary damage to system equipment occurs.

Load flow analysis test whether the customer voltage fits the standard. Voltage Drop is used to calculate current flows and voltage levels on electrical power distribution systems. We will use American National Standards Institute (ANSI) C84 standard to test our design that the service voltage should be 120±5%(Table 1).

Table 1. National Steady State Voltage Regulation Standards

Nominal	*Service*	*Utilization*	*Nameplate*	*NEMA*
Standard	**-5%, +%5**	**-13%, +6%**	**Motor**	**-10%, +10%**
120	114 - 126	104.4 - 127.2	115	103.5 - 126.5
208	197.6 - 218.4	181 - 220.5	200	180 - 220
240	228 - 252	208.9 - 254.4	230	207 - 253
277	263.2 - 290.9	241 - 293.6		
480	456 - 504	417.6 - 508.8	460	414 - 506
	bandwidth 10%	bandwidth 19%		bandwidth 20%

4.2 PROCESS

Fault Current Analysis:

Voltage drop Analysis:

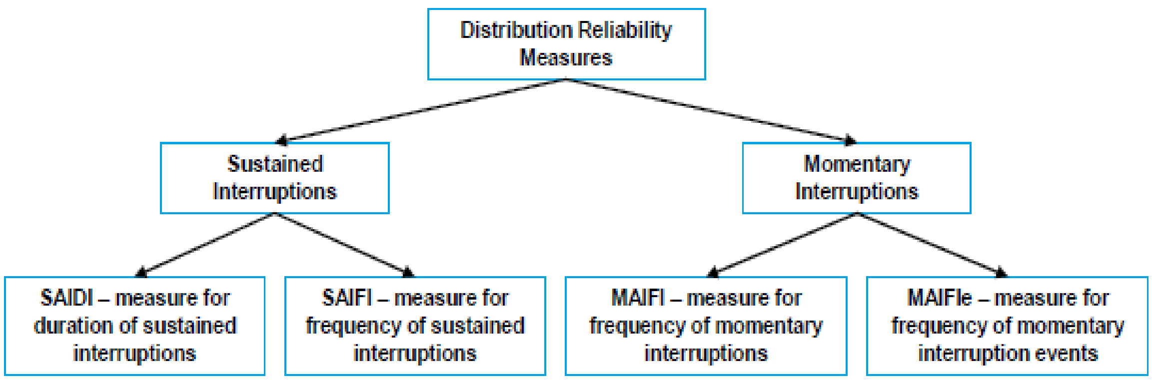
Calculate self impedance (Zaa, Zbb, Zcc, Znn) and mutual impedance (Zab, Zac, Zbc, Zan, Zbn, Zcn) are calculated using Carson's equation.

$$□□□ = □□ + 0.09530 + □ * 0.12134($$

$$□□□ = 0.09530 + □ * 0.12134($$

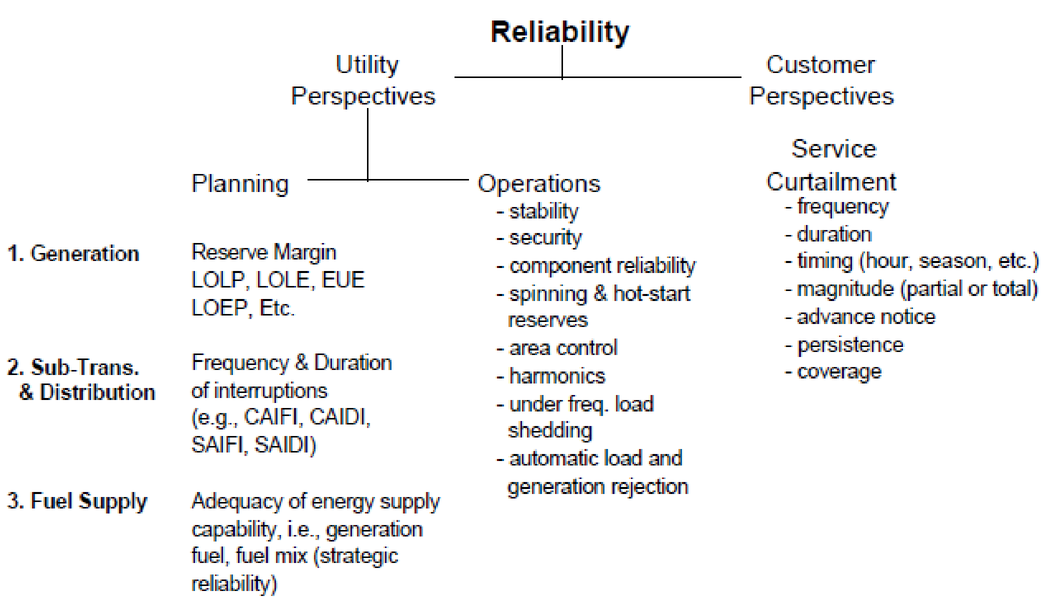
Based on self impedance and mutual impedance, we build Zabc impedance matrix and calculate line to ground voltage drops.

Distribution reliability measures process:



1:system average interruption duration index (SAIDI)
2:system average interruption frequency index (SAIFI)
3:momentary average interruption frequency index (MAIFI)
4:momentary average interruption frequency index event (MAIFIe)

Different perspectives of Reliability



5 Results

For the simulation part, we test fault current analysis and voltage drop analysis. Because we have two different substation to provide the power, we need to calculate the data of two whole line model and test. The fault current report and voltage drop report will be provide.

For the elevation part, we evaluate our design route from three field, space, reliability, and the cost. For the space part, we use the current demand data of Industrial company to expect the future demand data after the expand plant. Our design route should meet the expect the power demand. For the reliability part, we will calculate the SAIDI, SAIFI and some other variables. And we should satisfy those by utility which is ASAI>=0.9998,SAIFI<1, and CAIDI<2hours.

For the cost part, we already found the interest rate and inflation rate in 2017 in US and we also found the interest rate and inflation rate from 5 to 10 years in the future. We need these datas from Google because of the cost analysis for AMU. We will calculate the results to find how much money to maintain the equipment each year and how long AMU can get the cost of investment back with same value in the future because of the inflation.

6 Conclusion

In this project, we need to find a best way to support Industrial company with the highest reliable, highest flexible and lowest cost distribution system. The simulation and report of WindMil would be provided to prove the feasible of our design. And we would finish the reliability data in the WindMil circuit. Client can evaluate the interrupt rate from reliability data for every feeder. And the cost report will show the financial part. The goal of our project is to solve the problems for client- Algona Municipal Utilities. So the client can know the influence of our design in the financial field.

7 References

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8 Appendices

Figure 1

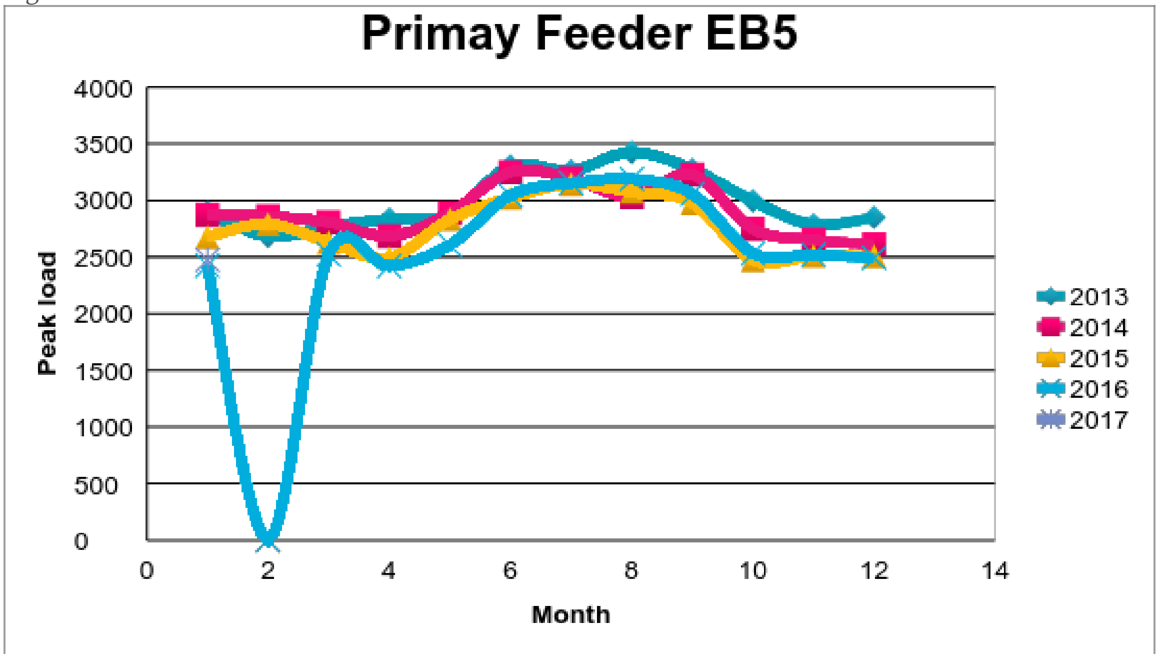


Figure 2

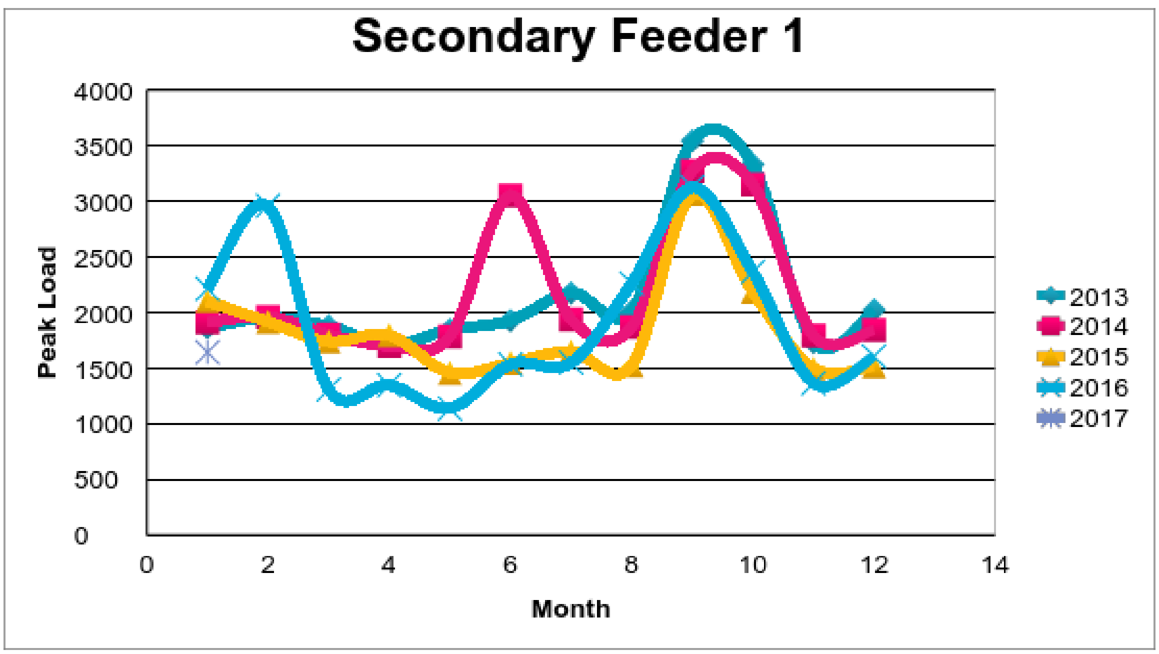


Figure 3

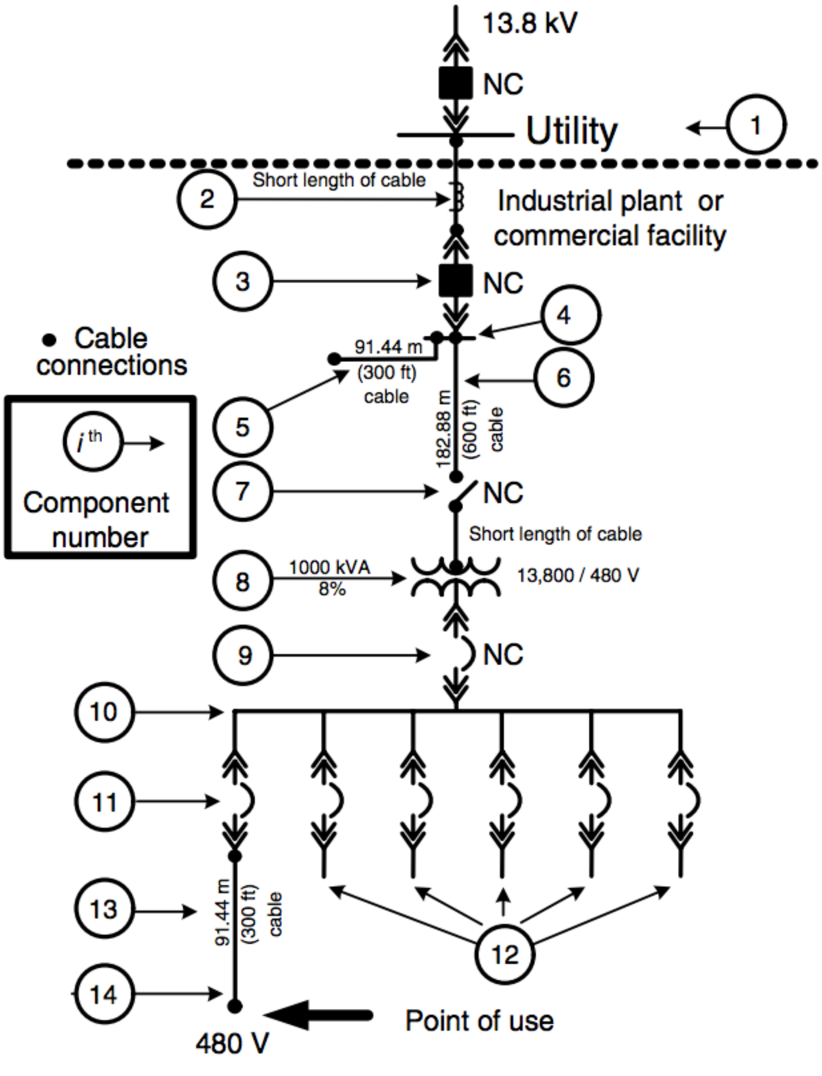
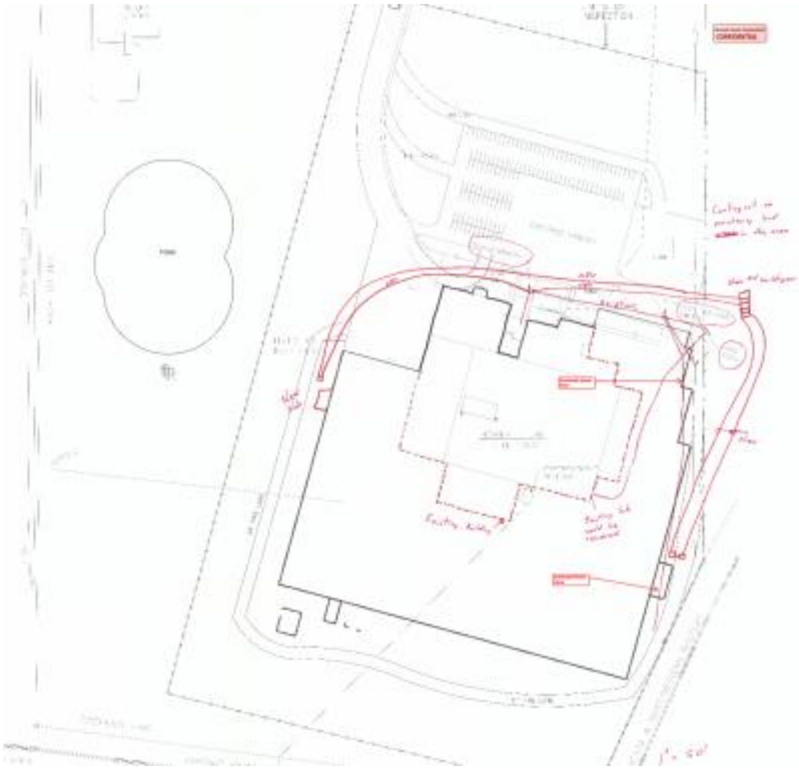
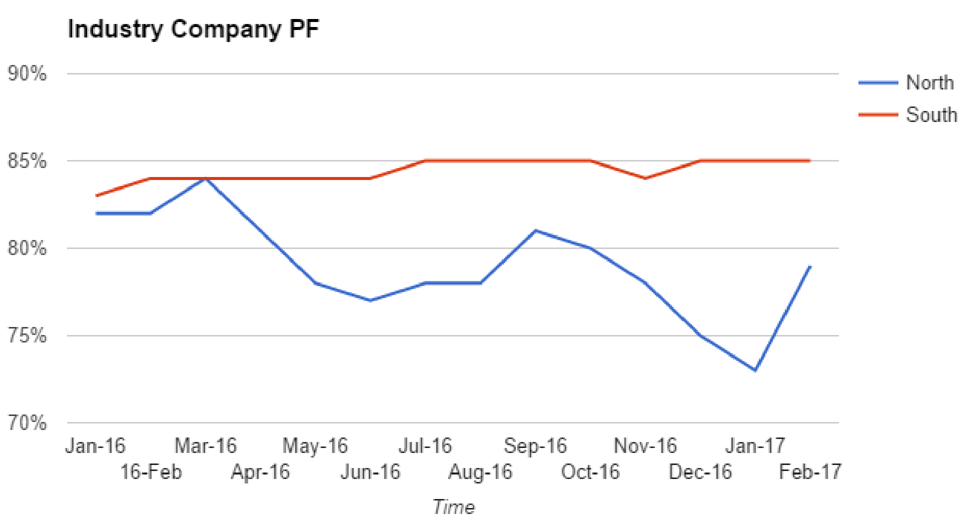

13.8 kV
NC
Utility
1
2
Short length of cable
Industrial plant or
commercial facility
3
NC
4
Cable
connections
91.44 m
(300 ft)
cable
6
182.88 m
(600 ft)
cable
5
i th
Component
number
7
NC
Short length of cable
8
1000 kVA
8%
13,800 / 480 V
9
NC
10
11
13
91.44 m
(300 ft)
cable
12
14
Point of use
480 V

Figure 4





Industry Company PF
90%
85%
80%
75%
70%
North
South
Jan-16
16-Feb
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
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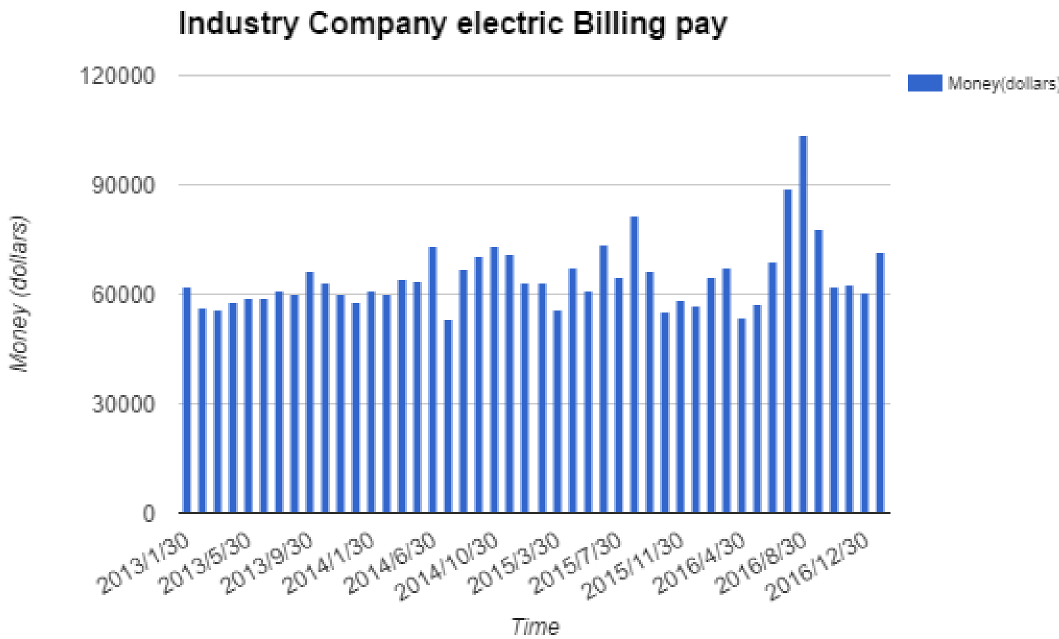
Nov-16
Dec-16
Jan-17
Feb-17
Time



Industry Company electric Billing pay
120000
90000
60000
30000
0
Money (dollars)
Money(dollars)
2013/1/30
2013/5/30
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2014/1/30
2014/6/30
2014/10/30
2015/3/30
2015/7/30
2015/11/30
2016/4/30
2016/8/30
2016/12/30
Time