Design Document for May 1611
Designing Optimal Distribution System Upgrades for Reliability and Growth in Lamoni, IA
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Introduction

Problem Statement

Lamoni is a growing community of 2,300 people in southern Iowa that is served by a municipal utility providing electricity, gas and water to the community. Lamoni would like to work with a team of students to help the utility choose the most cost-effective way to upgrade its distribution system to the east, and also the most cost-effective way to loop a distribution feeder that is currently providing radial service. Among the design elements are: route selection, lack of

breaker space in the substation, design optimization, switching voltage on existing feeders, and cost considerations of the updated system. Lamoni Municipal Power will provide one-line diagrams of current feeder configurations, data on power flows, design specifications of existing system and telephone support for questions from students.

Project Statement

Lamoni is powered by a substation rated for 10 MW. A feeder from the substation sends power out to the east end of Lamoni and has reliability issues. In order to relieve this issue, a radial line will be routed to help distribute power along with an existing overhead line. This will add redundancy to the system and help prevent future blackouts. The power line specifications and load data will be supplied by Lamoni Municipality Power for us to verify that the lines will be able to support the full load through a power flow analysis. The project team will also need to locate a viable route for the new underground radial line.

Deliverables

1) A report suitable for presenting to the utility governing body detailing the design recommendations, power flow analysis and cost analyses (net present worth of alternatives)
2) A timeline for the upgrades, suitable one-line drawings, distribution line routing plan, and equipment specifications

Specifications

This project aims to upgrade a distribution system that feeds power to the east side of Lamoni, Iowa. Lamoni Municipality Power would like to see several design options for a system that minimizes cost to the city and allows for future commercial growth. Due to city ordinances, any distribution lines that are built within Lamoni will need to be underground. The upgraded system will loop back to an existing overhead line and supply power to a 2 MW load on the east side of Lamoni.

System Level Design

System Requirements:

1. Must be cost-effective.
2. Must be able to handle both commercial and city growth in the upcoming years.
3. Must contain a parallel system of distribution lines that are looped back together to prevent line faults.
4. Must follow city ordinance.
5. Must provide a few design options for the Municipality to explore.

Functional Decomposition:

Option One:

A system interconnect is created between the Lamoni Municipal distribution system and the REC Southwest distribution system. This connection would be kept open except in the event of power loss on the east feeder, at which time the connection is closed and power is supplied to the end of the east feeder up to the fault. This solution would require power to be purchased at a wholesale rate set by REC Southwest in the event of a power outage, however when there is no power outage there would be no need to pay REC Southwest for the interconnect.

This would make part of the Lamoni system's reliability dependent on the REC distribution system. Since both lines, Lamoni's and REC Southwest's, are overhead lines the same fault conditions apply to both systems, however we believe the possibility of both lines faulting at the same time to be minimal. Another issue with this solution would be that REC Southwest would control the wholesale power rate that would be charged in times of a blackout, this rate could be changed in coming years as REC Southwest's situation changes. While this solution has these issues, it is the cheapest solution in terms of both time and cost. It would not cost much to build the interconnect, and the time needed to build this interconnect would be minimal.

Route for option one:

This is the interconnect with REC Southwest. This option would require a connection to be made with REC Southwest's Line. This would be made by running new overhead lines north on spruce drive to the existing REC southwest Lines. This is the only way to route this option as it will require an interconnect at the end of the existing feeder, and a connection to REC Southwest. This route would include mostly farmland, with trees close to or in the right of way. While this would require tree trimming or removal, this would be much cheaper than placing underground cable.

Option Two:

A feeder is added to the new generator site located across from the Lamoni Municipal Power building. Roughly 4500 feet of underground cable will run from the generator to Smith Street. The line will then be converted to an overhead line and run another 9000 feet to the interstate. The new overhead line will run parallel with the existing overhead line from the Municipality building to the interstate, where they will be looped together.

To improve reliability, we will need to have the two overhead lines on separate poles and different sides of the road. This will prove to be difficult because of easement issues. This option is the least reliable of the three options. This is because the overhead lines are very close together, and thus susceptible to the same fault conditions. For example, if high winds were to take down one line, there is a high probability that it would also take down the parallel line. It would also be the biggest eye sore with both overhead lines surrounding the road. However, it would be a cost effective way of providing reliability without having to buy power from Southwest.

Route for option two:

This option is to run partially underground and partially overhead. Because of the Amount of trees east of Smith Street the only viable way to run a loop for that section of the line is to run underground from the substation to Smith Street, after Smith Street it is viable to run overhead which will run from Smith Street to the end of the feeder. While the underground line can run within the same easement as the existing overhead line, once the line becomes overhead it will need to run in its own easement. For this there are two ways, one is to run the line along HWY 69 across the street from the existing overhead lines, however this would look unappealing to people and may be unpopular with the city. The other option would be to run it to the north end of the farmer's property on the north side of HWY 69 and then run at the edge of that property until the commercial section where it could rejoin with the existing line. This option would place the new line out of sight but would require a larger easement from the farmer and would decrease the amount of farmable land much more than simply running the line along HWY 69. Another issue with this plan is that it would make it much more difficult for the farmer to move farming equipment onto this section of land as both the north and south sides would have power lines, which would prevent large farm equipment from being transported. Because of these issues the farmer would be much less likely to give an easement for this plan, which makes it unfeasible as the client has stated that it would be impossible to use eminent domain to build this section.

Option Three:

A feeder is added to the new generator site located across from the Lamoni Municipal Power building. An underground cable of roughly 13,500 feet will run from the generator site to the interstate. This underground line will be ran parallel to the existing overhead line. Once the two lines reach the interstate, where they will be looped together. The load on the overhead line will be split with the underground line through a normally open switch. This will be the most expensive option but also the most reliable. If the overhead line were to fault in any circumstances, the underground line will be able to feed most of the load.

Routing for option 3:

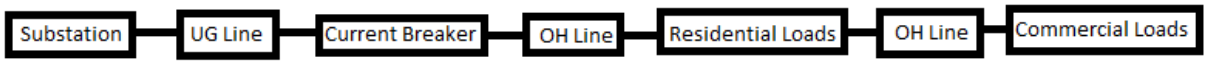
This option is to run underground cable from the substation to the end of the east feeder. The route that we found to be the most optimal was to run it along US 69 in the existing easement that is being used by the OH lines that currently make up the east feeder. This route has the advantage of not needing any additional easements, as well as being the shortest possible route to loop this feeder. Other options for this route include running the line on the opposite side of the road, however this would require additional easements and some cities do not like power being on both sides of the road. Another possible issue with this route is that it may be hard to put the underground cable in place without affecting the pre-existing distribution lines that make up the east feeder. For the option of running this line through a different route, this would increase the length of the line while bring up the same issues as placing the line on the other side of the road, mainly requiring new easements.

System Analysis

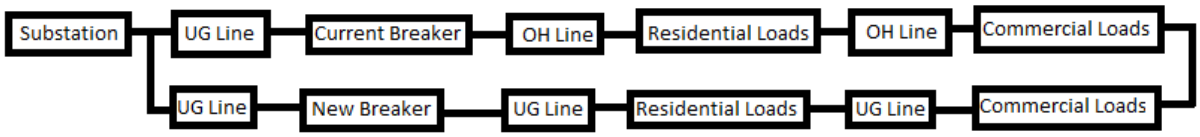
Currently, the east feeder has been experiencing reliability issues. Because of recurring faults, customers near the interstate have been losing power. With the existing system, the load has a peak around 2MW during the summer months. In options 1 and 3, the load would be split between the parallel lines which would add to the total capacity of the system. This is desirable for future growth of the load. In options 1 and 3, we would also install a breaker in the new generator site. This would not be needed for option 2 since we would be pulling power from SEC Southwest. Option 2 would essentially operate like the existing system until a line fault occurred. During a fault, the interconnect would close and allow REC Southwest to supply power up to the faulted area. All three options would provide greater reliability than the current system.

Block Diagrams

Current system:



Solution One:



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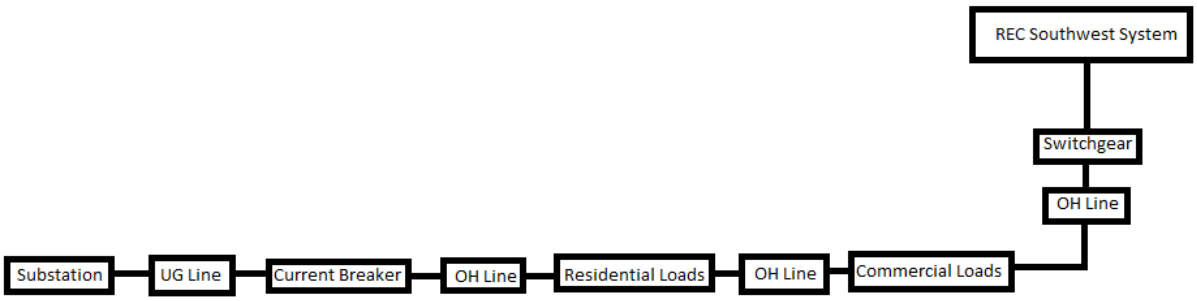
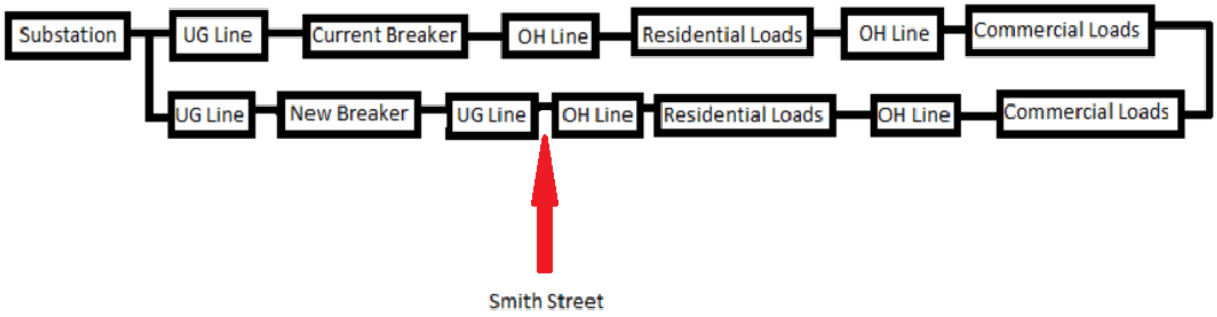
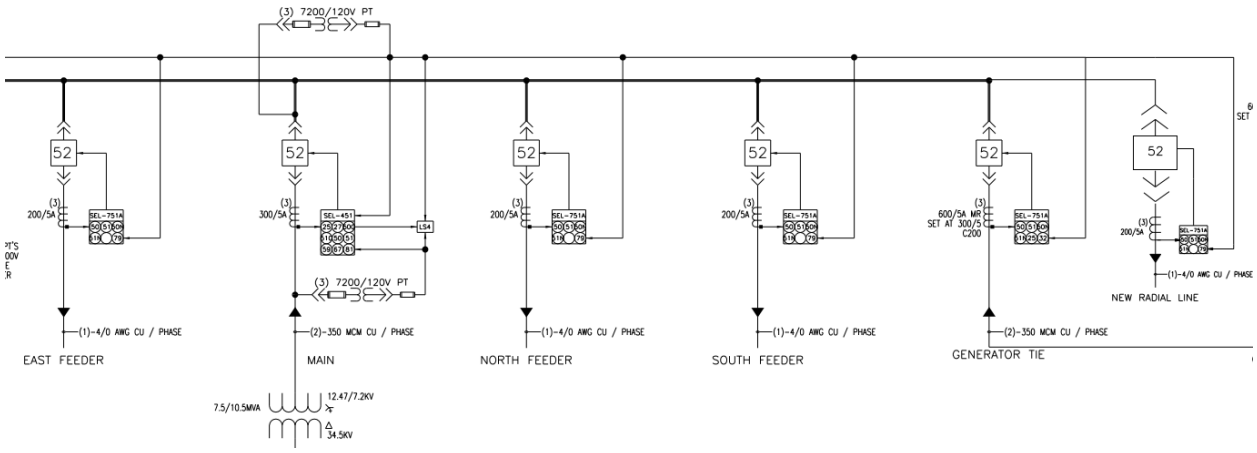


Solution Three:



This is our oneline that is applicable for options 2 and 3. A breaker will have to be added and this is what the oneline shows. The new breaker on this oneline is called "New Radial Line".



Detail Description

I/O specification

The added distribution line will be taking in a 10 MW source and outputting 12,470 volts to each consumer/customer. This is the only energized portion of our project.

Interface Specifications

There is already an existing interface used by Lamoni Municipal Power. Our design will be updated in their system.

Hardware/Software Specifications

The potential hardware that we would use is a 4/0 AWG 1/3 concentric neutral aluminum cable for a 200A circuit for the underground line.This cable was suggested to us by a professional engineering firm for a 200A capacity underground cable. This is the most cost-effective cable for our purpose. We have not determined what kind of cable we would use for the overhead line options.

Simulations and Modeling

We will be using computer software to run a power flow analysis and revise the system one-line. The one-line can be edited using MicroStation, and the power flow analysis can be done using PSSE (Power Transmission System Planning Software). We will be creating multiple one-line diagrams with our suggested system options. We will then run a power flow analysis on each system option to compare the results.

Implementations Issues and Challenges

The main challenges to implementation of an upgraded system will be city code and easement issues with placing power lines across Lamoni.

Testing, Procedures and Specifications

We will not be testing the options that we create. Rather Lamoni Municipal Power and the Engineering Firm will meet and decide what is the best path for the project.

Other Documents

CAD Mechanical, Electronic

Microstation Files will be provided to us from Lamoni Municipality.

PCB Issues

n/a

Software/ Firmware Design Documents

n/a

Conclusion

Due to the commercial growth of Lamoni, Iowa we have been asked to design a cost-effective way to upgrade their distribution system. The system requirements are that it must be cost-efficient, be able to handle growth of community and commercial, have a reliable loop system, follow city ordinance, and have a couple of options.

In conclusion, we will be designing a system upgrade for the city of Lamoni, IA. The city is currently being powered by a 10MW substation with a growing commercial district to the east side of Lamoni. To increase reliability, we will evaluate three options and decide which option best suits the town. Taking into account cost efficiencies, we will compose a report detailing our design and providing our calculations. Along with this report, we will submit one line diagrams, route plan, and power flow analysis to the Lamoni Municipality for further review.