Self Optimizing Grid Application Guide

(This document is **not** intended to supersede existing Distribution Standards)

Document Number: GDLP-ADM-GRS-00166

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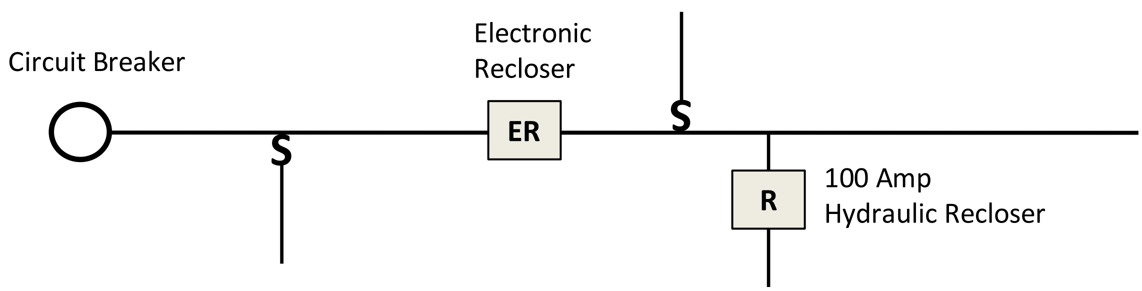
Current State:
The existing distribution grid consists mostly of individual circuits that fall into three categories with respect to sustained outages; radial circuits with no alternate source tie capabilities, circuits with alternate source tie capabilities via manual switches, and circuits on self-healing teams. Although the number of self-healing teams on our system is increasing, the percentage of circuits on a self-healing team is relatively low. Capacity rules concerning substation bank and circuit loading are not the same across the company. Utilizing alternate feeders to restore power to part or all of the load on a circuit that is experiencing a major outage is typically limited by equipment and conductor ratings and can be dependent on the time of day or year.

Sectionalization on each circuit typically consists of the breaker, a mainline midpoint recloser (hydraulic or electronic), along with laterals/taps off of the mainline that are protected by either a recloser or fuse. The term mainline is a generic term that differs based on the jurisdiction and is sometimes called the feeder backbone, circuit backbone and recloser subfeeder. These protective devices are coordinated in an effort to affect the fewest customers possible in the event of a sustained fault and outage. Sustained faults along the mainline typically result in all or a large portion of the customers on a circuit experiencing an outage. Although circuits with self-healing technology do isolate around sustained faults and restore power to un-faulted line segments, the number of customers that experience an outage tends to be high due to the number of customers on the faulted line segment.

Typical Existing Distribution Circuit

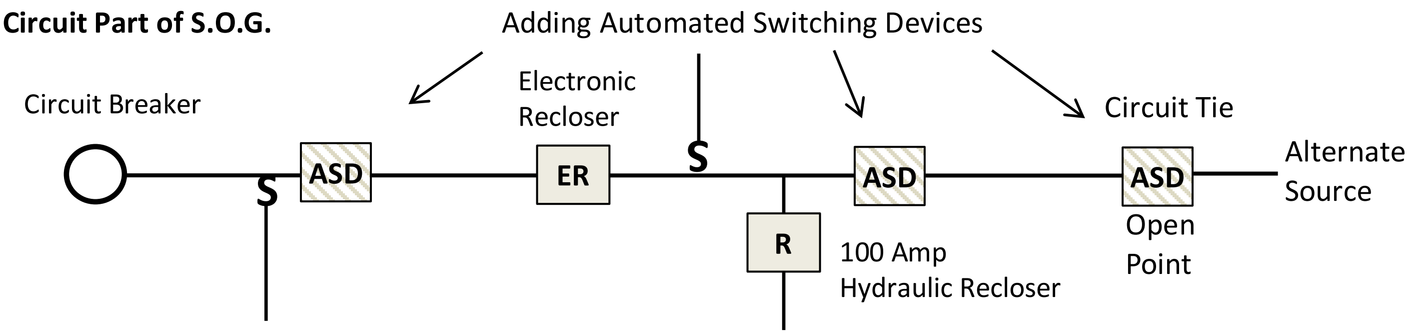


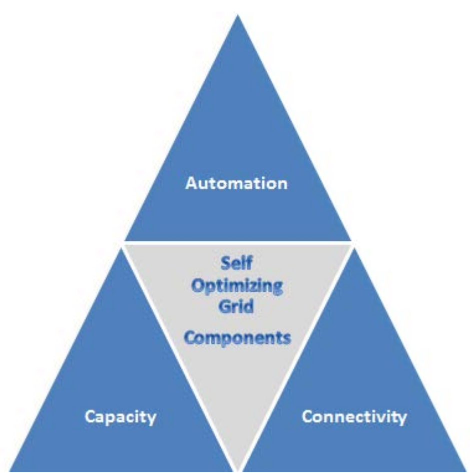
Self Optimizing Grid Purpose and Description

Future State:
Self Optimizing Grid (S.O.G.) is the concept of transforming the distribution system from a population of circuits with minimal automated alternate source capability, to a network of circuits with spare load capacity, automated inter-circuit connectivity and smaller automatically switchable line segments along the feeder backbone. With the integration of self-healing/Closed Loop FISR technology, a sustained fault will be automatically isolated to a smaller line segment, while all other un-faulted line segments are restored from alternate sources most of the time. The objective is to drastically change the customer experience through improved reliability.

Self Optimizing Grid will consist of three components: **Capacity, Connectivity** and **Automation** (see Section II). To become part of S.O.G, a circuit must meet all three component rules. Due to topology, not all circuits have potential alternate sources nearby. Also, some circuits have a lower customer count. As a result, the target is to apply all S.O.G. components to 80% of our distribution customers. The remaining 20% of our customers will have the Automation component applied only and will not be considered part of S.O.G. (see Section IV). However, they will still benefit from smaller line segments and SCADA enabled devices. The implementation of S.O.G. will result in the addition of SCADA enabled switchable devices between each line segment and at utilized circuit ties to alternate sources. Depending on the current state of capacity and connectivity to alternate sources, the work required to meet S.O.G. rules may include reconductoring, the installation of new circuit ties, line regulator upgrades and new installs, along with substation bank upgrades and additions.

Circuit Part of S.O.G.





Section I – Definitions

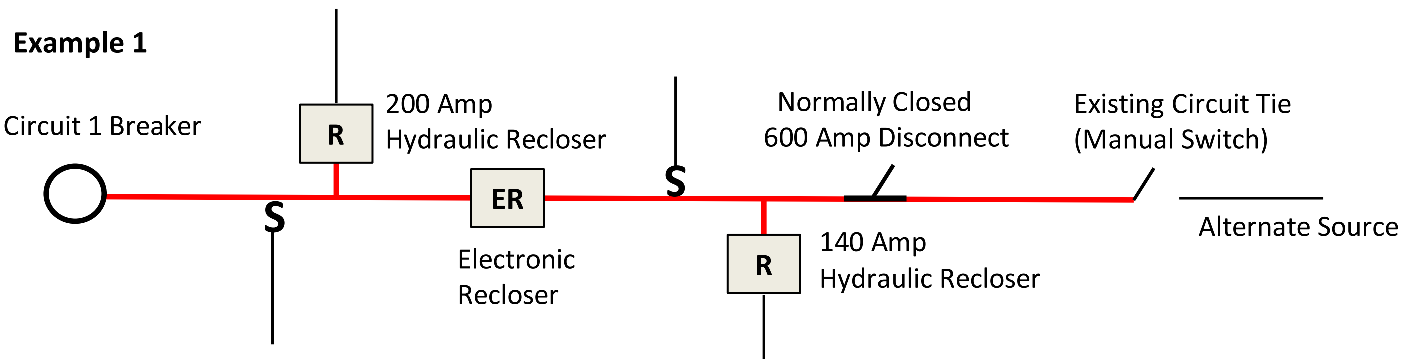
Feeder Backbone - definition to be used in applying the S.O.G. rules in this document

The Self Optimizing Grid <u>Feeder Backbone</u> of a circuit is defined as the following:

- All 3 phase, unfused line sections protected by a reclosing device larger than 200 amps, including the breaker.
- Any three phase line section protected by a reclosing device 200 amps or smaller with a circuit tie that will be utilized for self optimizing grid is considered feeder backbone.
- Any three phase line section protected by a reclosing device 200 amps or smaller without a utilized circuit tie is <u>not</u> considered the backbone.

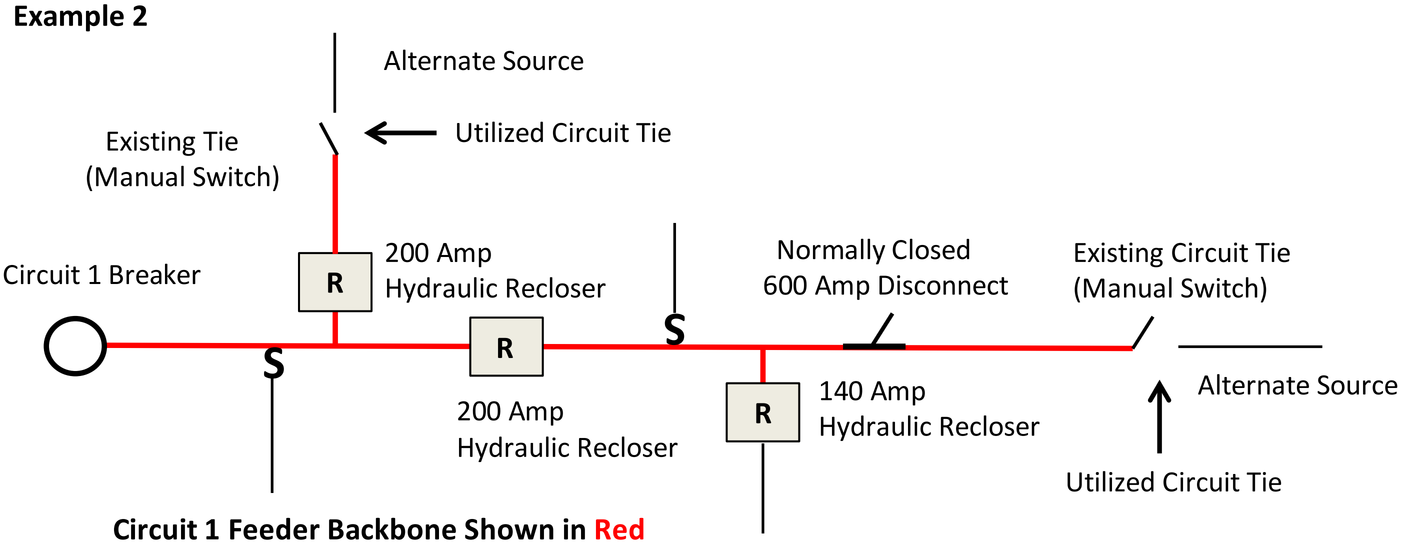
Background: The goal of the Self Optimizing Grid (S.O.G.) is to further segment our lines and add inter-circuit connectivity to automatically restore power to as many customers as possible in the event of a sustained fault. In most cases, load and customer count is high beyond electronic reclosers and as a result the line section beyond electronic reclosers is considered feeder backbone. In most cases, hydraulic reclosers have fewer customers and therefore the line section beyond hydraulic reclosers are not considered part of the feeder backbone except when there is a utilized circuit tie.

Example 1



Circuit 1 Feeder Backbone Shown in Red

Example 2



Circuit 1 Feeder Backbone Shown in Red

Definitions (Continued)

Alternate Source – An alternate electrical source used to restore power to un-faulted line segments during a major outage. This will typically be an adjacent distribution circuit. However, this could be a DER in a future state.

Utilized Circuit Tie – If a circuit has multiple existing circuit ties, not all circuit ties must be used and converted to automated devices under these standards. "Utilized" circuit tie refers to a circuit tie that will be converted to an automated device for restoration purposes under these standards.

Automated Switching Device (ASD) – As part of the Self Optimizing Grid standards, a key part to automation is having SCADA controllable field equipment that allows remote switching. The term "automated switching device" refers to a switchable SCADA controllable device. These devices will most likely be electronic reclosers setup as a switches, but in some cases may be setup as reclosers or sectionalizers.

Line Segment – A section of line on a distribution circuit bound by switching devices on all sides with the exception of circuit end points without a circuit tie.

Segmentation – The act of dividing a distribution circuit into switchable line segments for the purpose of fault isolation and restoration. All devices placed to define line segments in these standards will be SCADA enabled and controllable switching devices.

Section II – Self Optimizing Grid Components (Applies to Overhead and Underground)

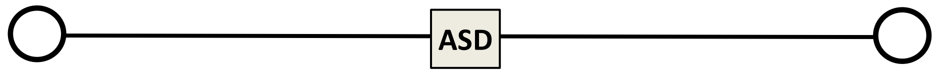
1.0 Capacity and Connectivity (Circuit Ties)

- Minimum Requirement: Any circuit part of Self Optimizing Grid (S.O.G.) shall be designed such that all of the circuit load can be restored from an alternate source(s) 90% of the hours in a year (90% Restoration Availability minimum requirement). This correlates to being able to restore all of the load on a circuit at approximately 75% of the projected peak load. **See Example 1 for application. See below for further explanation of how this percentage was derived.**
  Exception: Restoration at 75% of projected peak load in order for the average circuit to be restored 90% of the hours in a year is based on retail system load data. If substantial capacity work is required in order to meet this requirement and individual hourly circuit load data is available, circuit level data can be used to determine a more accurate % of projected peak load to meet the 90% Restoration Availability minimum requirement. Follow the steps on page 7 (next page) to determine an individual circuit % of projected peak load.
- Restoration of load to meet the 90% Restoration Availability minimum requirement shall not exceed the emergency thermal ratings of any distribution equipment including the substation bank, circuit breaker, the wire, reclosers, automated switching devices, regulators and inline disconnects.
- When performing a circuit study, the alternate source(s) substation bank loading should also be considered at 75% of projected peak.
- Multiple alternate sources per circuit can be utilized to meet the 90% Restoration Availability minimum requirement, if available.
- Alternate source(s) used to meet the 90% Restoration Availability minimum requirement should preferably include circuits from a different substation or from a different bank in the same substation if possible. **Note: While it is preferred to have an alternate source(s) from a different substation or bank, this is not a requirement. The minimum requirement is to be able to restore a single circuit, i.e. single circuit loss contingency.**
- If the only possible alternate source is from a circuit on the same substation bank, the circuit tie point should be in a location on the circuit in which at least half of the circuit customer count is upstream. A circuit tie close to the substation adds limited value for restoration. Use engineering judgment in accessing the reliability benefits in this scenario.

Percent of Projected Peak Load Derivation :
Hourly system load data was obtained for multiple years in each jurisdiction. For each year, the peak load hour was identified. The remaining hours of the year were then compared to this peak to determine an hourly percentage of that peak. 90% of the hours in a year equates to 8760 X .9 or 7884 hours. This also represents a possible unavailability of 10% or 876 hours per year. By sorting the hourly data from highest to lowest, the percentage of peak load for which at or below represented approximately 90% of the hours for each year was established. For example, in DEF for 2014, there were 790 hours in which the system hourly load was higher than 75% of the annual peak hour of that year. There were also 7970 hours in 2014 in which the load was below 75% of the annual peak hour, which equates to a 91% availability. All jurisdictions were very close to 75% and as a result, 75% of projected peak load should be used unless you have data to calculate the percent for an individual circuit.

Example 1: (Both Circuits are 12.47KV)

Circuit Breaker **Circuit Tie** **Circuit Breaker**



Circuit 1
Alternate Source
for Circuit 2

Projected Peak Load
6.48 MVA
300 Amps

Automated
Switching Device

A balanced load is
assumed in this example

Circuit 2
Alternate Source
for Circuit 1

Projected Peak Load
7.02 MVA
325 Amps

Circuit 1 and Circuit 2 are the only alternate sources for each other in this example, similar to a typical two circuit self-healing team. Applying the 90% restoration availability minimum requirement results in the following load assumptions in considering capacity compliance:

Circuit 1 load at *75% of peak = 0.75 X 6.48 MVA = 4.860 MVA(total), 225 amps/phase
Circuit 2 load at *75% of peak = 0.75 X 7.02 MVA = 5.265 MVA(total), 244 amps/phase

If Circuit 1 restores all of the load of Circuit 2, the capacity of the bank, wires (including both sides of the circuit tie), voltage regulators, switching devices, etc., must be able to carry an extra 5.265 MVA, plus the existing load of 4.860 MVA without exceeding emergency thermal ratings. Note: When considering if the substation bank for circuit 1 has capacity to pick-up the additional load of circuit 2, assume the bank is also loaded at 75% of projected peak.

If Circuit 2 restores all of the load of Circuit 1, the capacity of the bank, wires (including both sides of the circuit tie), voltage regulators, switching devices, etc., must be able to carry an extra 4.860 MVA, plus the existing load of 5.265 MVA without exceeding emergency thermal ratings. Note: When considering if the substation bank for circuit 2 has capacity to pick-up the additional load of circuit 1, assume the bank is also loaded at 75% of projected peak.

Individual Circuit % of Peak Load Determination (in Excel)

Step 1: Obtain circuit level hourly load data for at least one year. You can use more frequent data if available.
Step 2: Filter out outages, blanks, etc.
Step 3: Sort all load data from largest to smallest with all data in one column.
Step 4: Click on the top of the load data column and view the bottom to see the total data "count". This is needed in figuring out the 90% availability.
Step 5: In a column next to the load data, divide each row of load data by the peak load. This will give you a percentage of peak load for each row.
Step 6: Multiply the total data count by 0.1. This is the number of load data points that are at or above 90% availability.
Step 7: Scroll down until the row number equals the count calculated in step 6. This represents the percentage of peak load that equates to 90% availability.

2.0 Automation (Includes segmentation and self healing/FISR integration)

The feeder backbone will be will be transitioned to automated switchable segments. See Section I for feeder backbone definition. Segment target characteristics are:

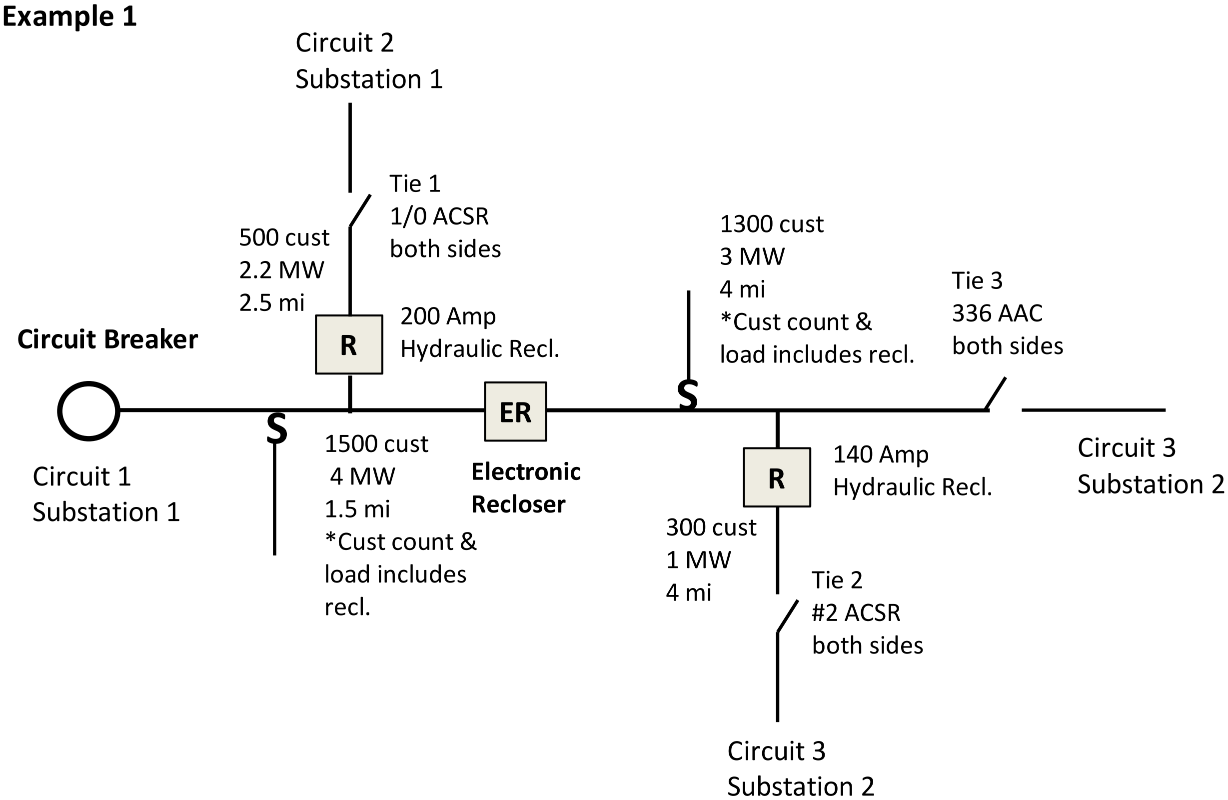
- No more than 400 customers in the segment. *
- No more than 3 miles of exposure in the segment.*
- No more than 2 MW load in the segment. *

  *These are general guidelines that will vary depending on field conditions. Note that the segment load target is based on meeting 90% availability rule (75% of projected peak).

  - New switches installed to define segments will be automated, including utilized circuit ties. Existing manual switches and hydraulic reclosers that define segments will be converted in accordance with these Automation rules.
  - Planning engineers and Grid Management will use current standards and engineering judgment for additional segmentation switches (critical customer feeds, T points, OH to UG, etc.).
  - Segments will have adequate fault protection and coordination between devices to facilitate the ability for load transfers between circuits.
  - Voltage levels should be maintained within ANSI C84.1 Range A (minimum 114V at the meter), whenever there is a segment transfer. When performing a circuit analysis to ensure voltage levels are maintained during a reconfiguration, limit that analysis to adjacent interconnected circuits only.
  - All substation circuit breakers must have electronic relays and are SCADA enabled and controllable.
  - Self-healing/Closed Loop FISR will be enabled on each circuit after work is complete for the appropriate Self Optimizing Grid components.
  - **Feeder backbone segmentation exception:** If a line segment has no feasible circuit tie, is protected by a reclosing device regardless of size and has 700 or more customers, further segmentation should be performed. Any segmentation should utilize automated switching devices.

3.0 Automation and Connectivity (Circuit Ties) Examples

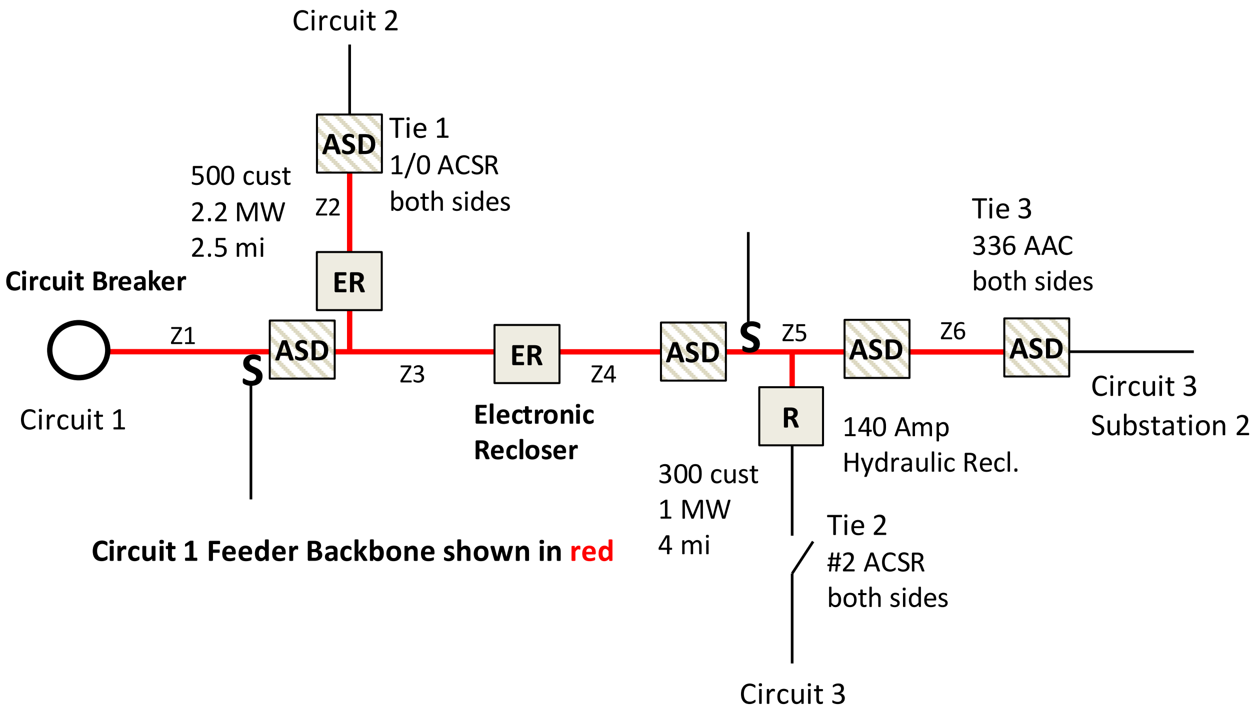
3.1 Example 1



Background:

- All segment loads shown are at 75% of peak.
- All load of Circuit 1 can be picked up from **Circuit 3** per the capacity rules through **Tie 3**.
- Tie 1 and Tie 2 can only pick up partial load but add some redundancy.
- The line segments downstream of both the 200 and 140 amp hydraulic reclosers exceed SOG line segment rules.
- Circuits 1 & 2 are fed out of the same substation and bank.
- Circuit 3 is out of a different substation.

3.1.1 Example 1 Solution



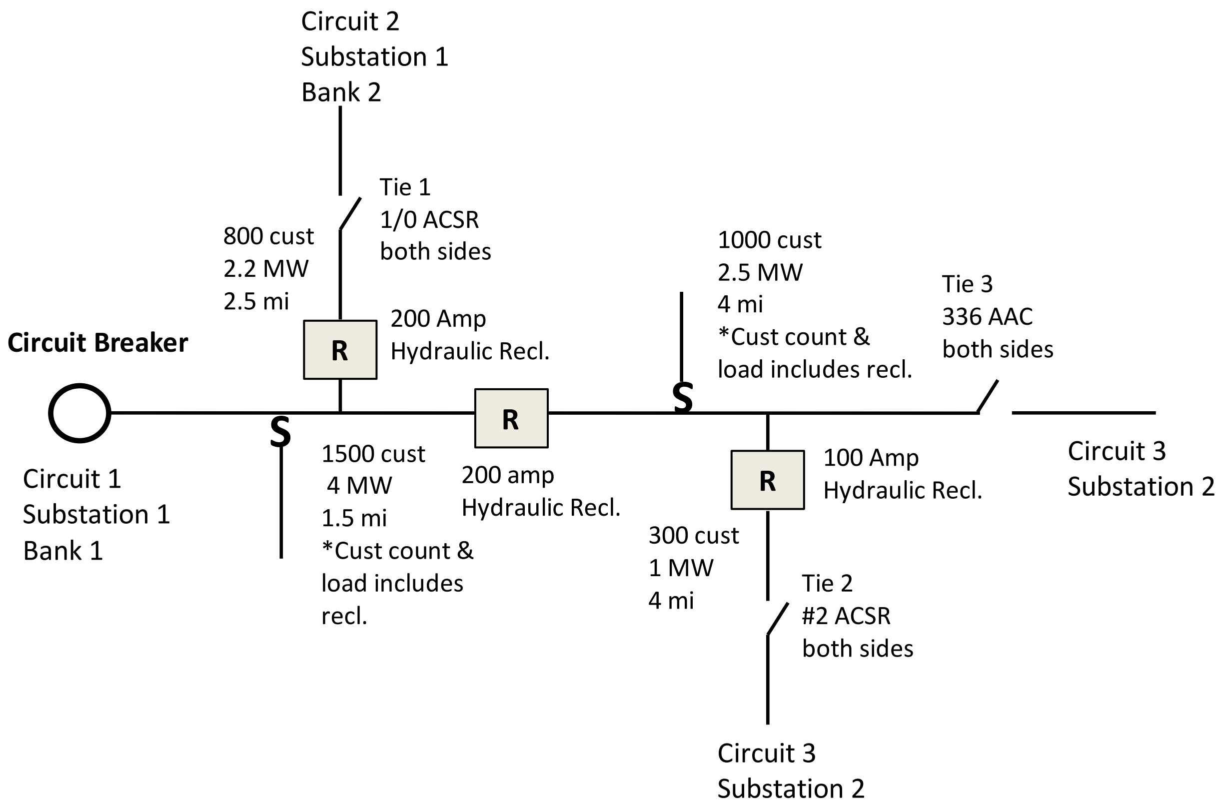
Circuit 3 is capable of picking up all of the load of Circuit 1 and is out of another substation making it the highest priority tie at the lowest cost to utilize. Tie 1 is considered a weak tie and is out of the same substation and bank. However, not utilizing this tie would result in a zone with 950 customers. Utilizing this tie will result in a lower zonal customer count, plus replace an existing hydraulic recloser. It should be noted that this was an engineering judgment decision based on the relative low risk of a bank failure versus the expected benefits. In the event of a bank failure, Circuit 3 can still pick up all of the load. By definition, since Tie 1 is being utilized, the line segment beyond the old 200 amp hydraulic recloser becomes part of the feeder backbone shown in red. Tie 2 is also considered a weak tie, with very little spare capacity. Increasing the capacity and adding automated devices for Tie 2 is not justified and therefore, by feeder backbone definition, the line section beyond the 140 amp hydraulic recloser is not feeder backbone.

Zone Information:

Z1 – 550 customers, 0.8 MW, 1.1 miles Z4 – 450 customers, 1.1 MW, 1.4 miles
Z2 – 500 customers, 2.4 MW, 0.5 miles Z5 – 500 customers, 1.2 MW, 1.0 miles
Z3 – 450 customers, 0.8 MW, 0.8 miles Z6 – 350 customers, 0.7 MW, 0.9 miles

Average Customers per Line Segment = 467
Average Load per Line Segment = 1.17 MW
Average Distance per Line Segment =0.95 miles

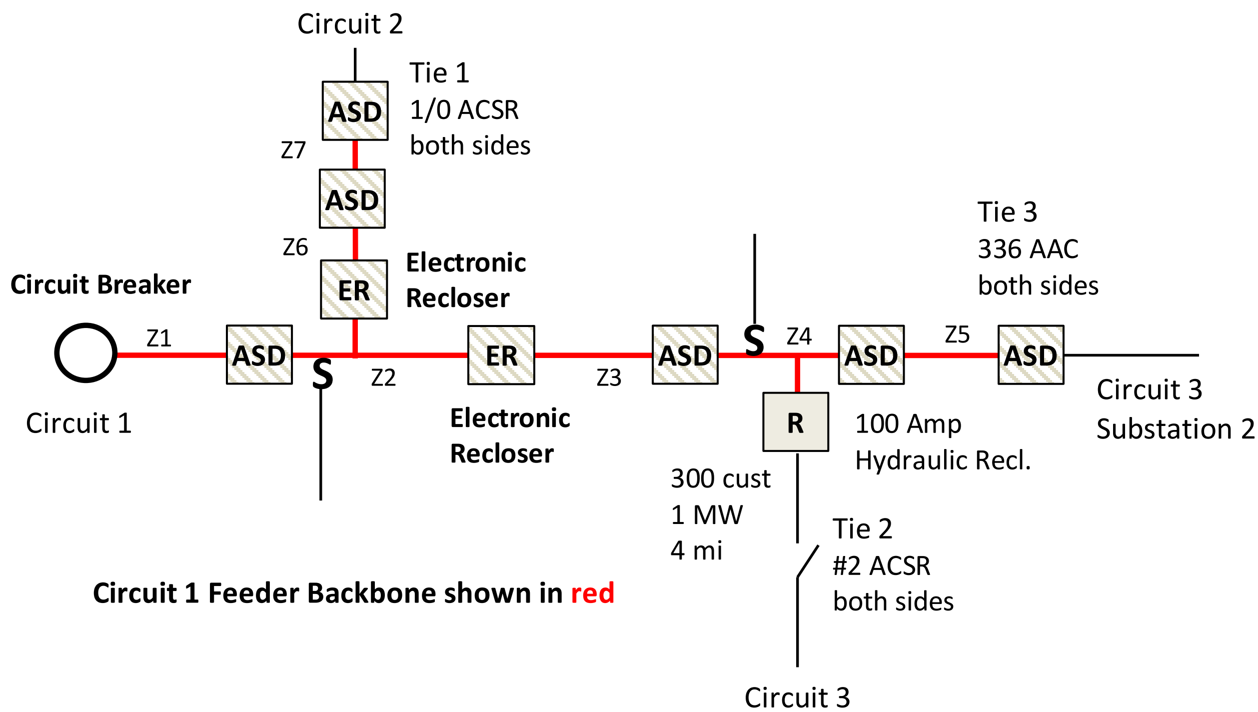
3.2 Example 2



Background:

- All segment loads shown are at 75% of peak.
- All load of circuit 1 can be picked up from **Circuit 3** per the capacity rules through **Tie 3**.
- Tie 1 and Tie 2 can only pick up partial load but add some redundancy.
- Circuits 1 & 2 are fed out of the same substation but on different banks.
- Circuit 3 is out of a different substation.

3.2.1 Example 2 Solution



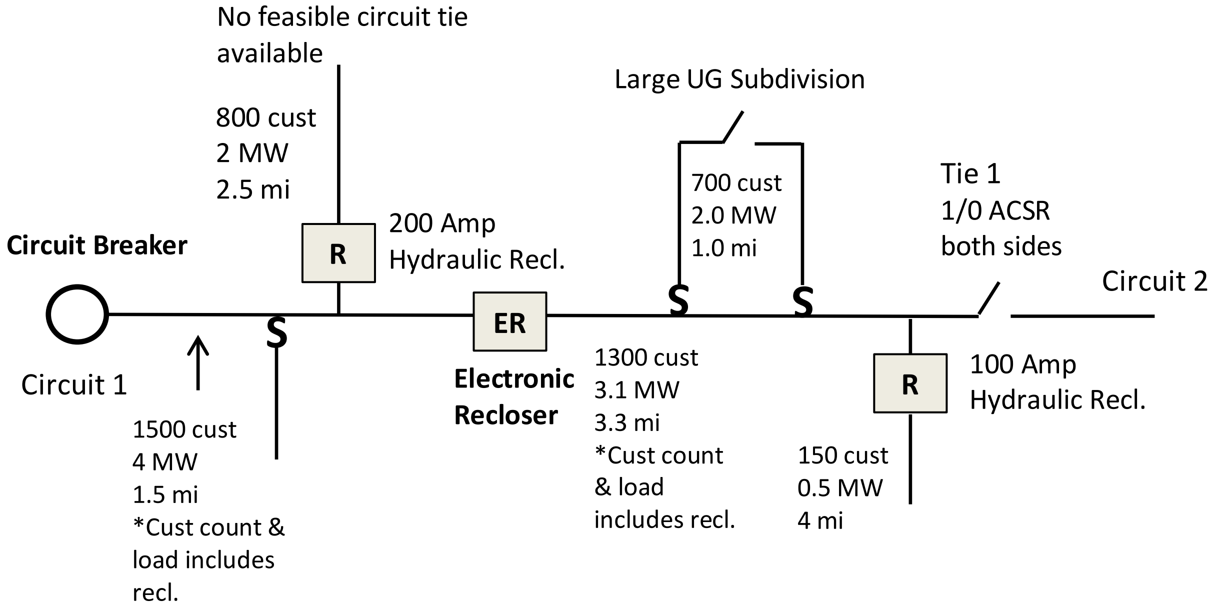
Circuit 3 is capable of picking up all of the load of Circuit 1 and is out of another substation making it the highest priority tie at the lowest cost to utilize. As a result of Tie 3 being utilized, the line section beyond this recloser is considered the feeder backbone and therefore is segmented and automated accordingly. Although Tie 1 is not a full capacity tie and this lateral is protected by a 200 amp hydraulic recloser, the line section has a high customer count and the alternate source is a circuit on a different bank. Therefore, this line section is also considered feeder backbone and as a result is subject to be further segmented and automated. Tie 2 is considered a weak tie, with very little spare capacity. Increasing the capacity and adding an automated device for Tie 2 is not justified.

Zone Information:

Z1 – 300 customers, 0.8 MW, 1.1 miles
Z2 –400 customers, 1.0 MW, 0.5 miles
Z3 – 350 customers, 0.6 MW, 0.8 miles
Z4 – 400 customers, 1.3 MW, 1.4 miles
Z5 – 250 customers, 0.6 MW, 1.0 miles
Z6 – 450 customers, 1.2MW, 0.9 miles
Z7 – 350 customers, 1.0 MW, 0.8 miles

Average Customers per Line Segment = 357
Average Load per Line Segment = 0.93 MW
Average Distance per Line Segment =0.93 miles

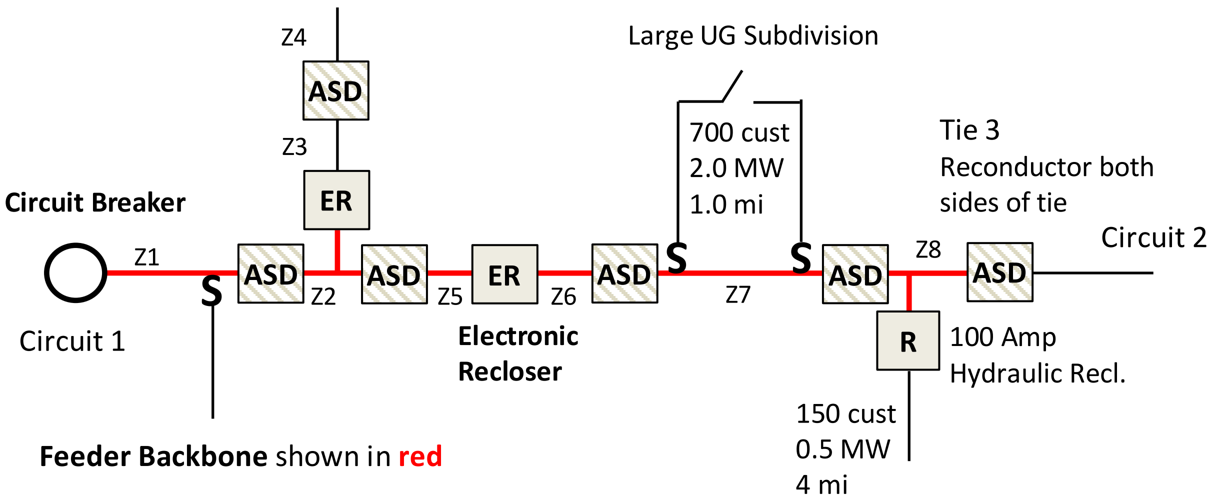
3.3 Example 3



Background:

- All segment loads shown are at 75% of peak.
- The only available existing circuit tie is Tie 1, which does not meet the capacity rules due to the small conductor.
- Circuit 2 is out of another substation.
- The line segment downstream of the 200 amp hydraulic recloser has 800 customers, above the segmentation rule for reclosing devices with no feasible tie.
- A very large looped subdivision exists downstream of the electronic recloser.

3.3.1 Example 3 Solution



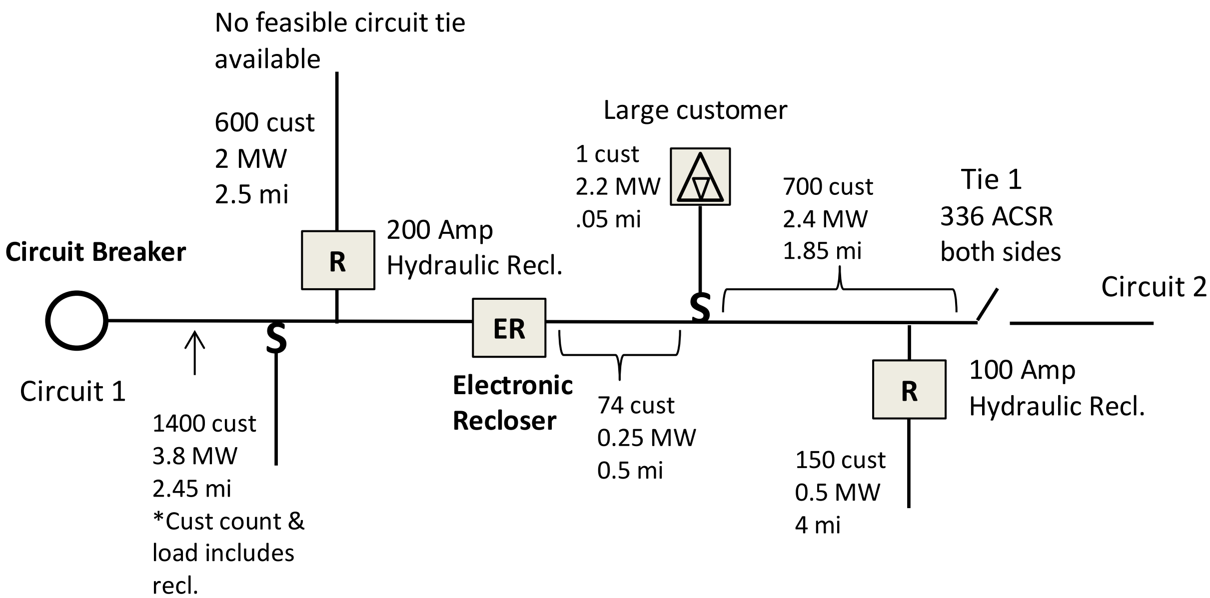
Circuit 2 is capable of picking up all of the load of Circuit 1 from an equipment and bank capacity perspective, but the 1/0 ACSR around the tie point is not adequate. Reconductoring must take place on both sides of the tie to meet capacity rules. The 200 amp recloser has 800 customers, meaning it is drastically higher than the 400 customer count segment target. Even though there is not a feasible tie point for back-feeding, the section of line beyond the 200 amp hydraulic recloser is subject for further segmentation and automation based on the feeder backbone segmentation exception on page 8. Because there is no tie point, this line section is **not** considered feeder backbone. A situation with this many customers beyond a hydraulic recloser should be rare, but does exist. Beyond the existing electronic recloser, the tendency would be to place a device between the two dips of the large underground subdivision in an effort to lower the customer count per segment. However, doing so creates operational concerns due to potentially having two different circuits feeding this subdivision if the tie point moves in the future. Therefore, automated switching devices were installed on both sides of these dips. Reference: Legacy Progress Engineering manual – Section 9.0, part D, Legacy DEC Engineering Resources manual – Section 9.4, Enterprise Wide Construction manual Section 20. There may be cases in which segmenting outside of the dips will result in very large segments due to the distance between dips. Consider utilizing ASD's to prevent a loop split or splitting the loop into two loops.

Zone Information:

Z1 – 400 customers, 0.9 MW, 1.1 miles
Z2 – 850 customers, 2.5 MW, 0.5 miles
Z3 – *400 customers, 1.0 MW, 1.3 miles
Z4 – *400 customers, 1.0 MW, 1.2 miles
Z5 – 250 customers, 0.6 MW, 0.8 miles
Z6 – 325 customers, 1.1 MW, 1.4 miles
Z7 – 700 customers, 1.2MW, 1.0 miles
Z8 – 275 customers, 0.8MW, 0.9 miles
*Z2 includes the customer count and load of Z3 and Z4.

Average Customers per Line Segment = 467
Average Load per Line Segment = 1.18 MW
Average Distance per Line Segment =0.95 miles

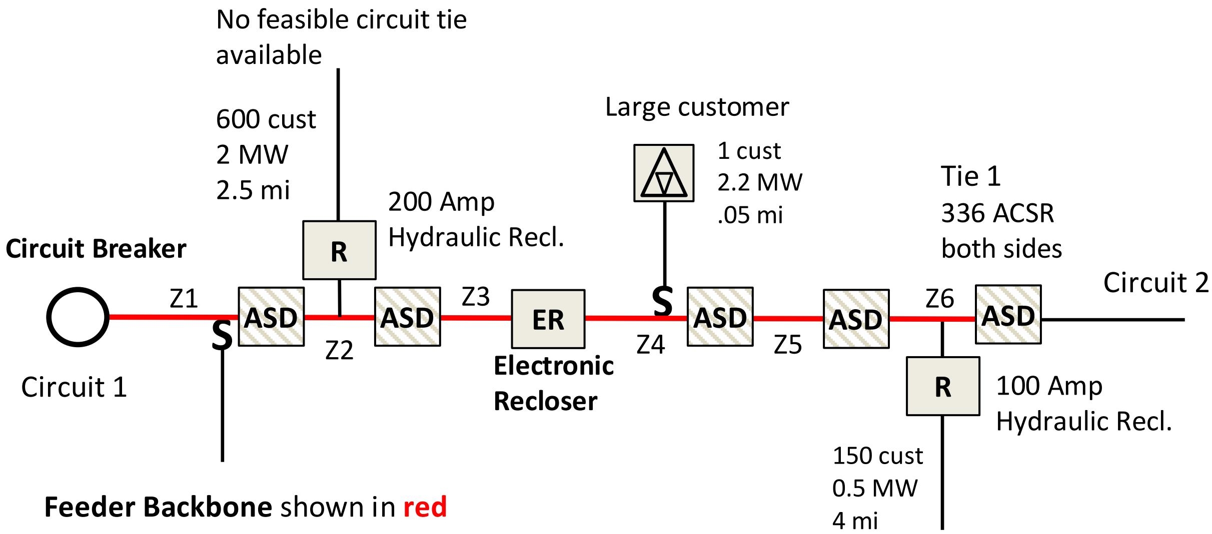
3.4 Example 4



Background:

- All segment loads shown are at 75% of peak.
- The only available existing circuit tie is Tie 1.
- Circuit 2 is out of another substation.
- The line segment downstream of the 200 amp hydraulic recloser has 600 customers, below the 700 or more exception for further segmentation.
- There is a large single customer off the backbone.

3.4.1 Example 4 Solution



Circuit 2 is capable of picking up all of the load of Circuit 1 from an equipment and bank capacity perspective. The 200 amp recloser has 600 customers with no feasible circuit tie. The customer count is below the segmentation threshold of 700 customers for radials. As a result, no further segmentation is justified. The 200 amp recloser can be changed out to an ASD through the oil filled recloser replacement budget in the H&R program. Because there is no tie point, this line section is **not** considered feeder backbone. There is a large customer below the existing electronic recloser that is greater than the segment target. By the segment target for load, ASD's should be placed on both sides of the customer along the feeder backbone. While this was no issue on the downstream side, placing an ASD on the upstream side would create a segment with only 74 customers and very little load. Although not placing the additional upstream ASD increased the segment load even more, the additional load was minimal and avoided an extra device.

Zone Information:

Z1 – 400 customers, 1.0 MW, 1.0 miles Z4 – 75 customers, 2.45 MW, 0.5 miles
Z2 – 625 customers, 2.1 MW, 0.35 miles Z5 – 450 customers, 1.5 MW, 1.1 miles
Z3 – 375 customers, 0.7 MW, 1.1 miles Z6 – 400 customers, 1.4 MW, 0.75 miles

Average Customers per Line Segment = 488
Average Load per Line Segment = 1.53 MW
Average Distance per Line Segment = 0.8 miles

Section III – Work Flow Process

1.0 Self Optimizing Grid Circuit Identification and Prioritization Rules

1.1 Background and Initial Circuit Identification:

The Grid Improvement Plan target is to have 80% of our customers on the Self Optimizing Grid. 80% of our customers are on approximately 60% of our circuits. Therefore, the top 60% of our highest customer count circuits will be targeted per jurisdiction as a starting point in determining which circuits will become part of the S.O.G. Circuits equal to or above the customer count listed below are to be considered first for becoming part of S.O.G.

Jurisdiction	Circuit Customer Count
DEI	725
DEO	1060
DEK	1025
DEC	880
DEP	1155
DEF	1400

Note: The above criteria is a general guideline in determining what circuits should be in scope for S.O.G. Even though a circuit may meet the customer count criteria above, it may be excluded due to other factors such as no feasible ties or alternate sources. Also, there will be circuits that are below the listed customer count that will become part of the S.O.G. due to the proximity to circuits that do meet the customer count.

1.2 Annual circuit prioritization should be based on the following in order:

From the population of circuits selected by using the chart above, use the following items in sequential order to further target/identify circuits annually. Go through <u>all</u> 7 items before making circuit selections. Selecting S.O.G. circuits in this manner is expected to result in a higher reliability impact earlier in the program.

1. **Customer count** - Choose circuits with the highest customer count.
2. **Load growth** – Circuits requiring capacity upgrades as a result of load growth should be coordinated with S.O.G. work. The intent is to prevent capacity rework as a result of S.O.G.
3. **Historically poor reliability** – Choose circuits with the worst reliability.
4. **Available circuit tie to alternate source** – To increase early cost benefit, choose circuits with existing circuit ties to alternate sources early in the program if possible.
5. **No substation upgrade work required** – To increase early cost benefit, choose circuits that do not need substation upgrade work (New or larger bank, a new circuit breaker, or relay) early in the program if possible.
6. **Lowest cost*** – Choose circuits where the least amount of work is needed.
7. **Societal impact** – Choose circuits that have societal impacts such as hospitals and airports.

***Note:** Determining a highly accurate estimate of the lowest cost circuits can be more difficult, requiring circuit modeling for final determination. However, for circuit selection in item 6 above, consider if work will be needed concerning Connectivity and Capacity components only (wire, regulators and substation bank). Automation will be performed on every circuit regardless of S.O.G.

1.2.1 Alternate Sources

- Any circuit that will serve as the only alternate source for another circuit that is part of S.O.G. should also be brought up to S.O.G. standards even if the circuit is below the circuit customer count guidance.
- If a circuit does not meet the circuit customer count and is one of multiple alternate sources to another circuit part of S.O.G., this circuit is not required to be part of S.O.G., but should eventually be segmented and automated along the feeder backbone. Use engineering judgment in these cases.

1.3 Next Steps

- Each potential circuit should be studied to understand the full scope of work in applying and meeting all three components (capacity, connectivity, automation) of S.O.G. Once the scope of work required has been determined, the remaining items below (2.0 – 5.0) should be referenced for work generation.

1.4 Visualization Tool

The Visualization Tool can be utilized to assist in year to year planning to quickly identify potential issues around lack of ties, weak ties and small conductor. This tool provides a SOG growth area view by year that can potentially be used for planning beyond the next year. A full study will still need to be performed on each circuit. See the Visualization Tool Manual below:

SOG Visualization Tool - Manual V6 201ɛ

SOG Visualization Tool - CheatSheet V2

2.0 S.O.G. Work Process Steps and Owners (Per Circuit)

Work Process Steps	DEO/DEK/DEI	DEC/DEP	DEF
1. Create Kickoff (Shell) W.O.	Grid Solutions (G.S.)	Grid Solutions (G.S.)	Grid Solutions (G.S.) Planning Engineer
2. Attach Scope Documents to Kickoff W.O.	* Capacity Planning	Capacity Planning	Grid Solutions (G.S.) Planning Engineer
3. Forward Kickoff (Shell) W.O. to	Cust Delivery PM	E&TCR	Contractor – Automation Cust Delivery PM - C&C
4. Create all Needed W.O.'s Per Circuit	Project Controls	E&TCR/Contractor	Contractor – Automation Cust Delivery PM - C&C
5. Design Job for Construction	E&TCR/Contractor	E&TCR/Contractor	Contractor

*For segmentation devices, info is entered in a workbook/template

3.0 S.O.G. Circuit Work Order Structure and Creation

The chart below refers to the work order (W.O.) structure per circuit for SOG work. **1)** Grid Solutions will create the initial Kickoff (Shell) W.O. per SOG circuit. This W.O. is intended to hold all capacity planning generated analysis and scope documents. **2)** Attach all scope documents to the Kickoff W.O. **3)** Forward Kickoff W.O. **4)** Utilizing the Kickoff W.O. and attachments, the remaining W.O.'s are created for the circuit. **5)** Design jobs for construction. All W.O.'s should utilize the common naming convention and include the circuit number, along with using "Related Record" Ref Type "SOG" and Ref Value "Circuit #" to link all SOG W.O.'s per circuit for tracking purposes. See next page for common W.O. description naming conventions. See W.O. creation job aid below. Exception: Capacity (inside fence) work is initiated via a communication from Capacity Planning to the Transmission organization.

Analysis	**Automation** (Segmentation device Installs. Includes tie devices)	**Connectivity** (Excludes tie devices)	**Capacity Outside Fence** (SOG Driven Circuit Capacity Work)	**Capacity Inside Fence** (SOG Driven Sub Capacity Work)
Kickoff (Shell) W.O. for scope/analysis attachments. **Job Plan =** SGSELFHEAL **Related Record** Ref Type=SOG, Value=ckt# **Grid Solutions: Creates Kickoff W.O.'s for each circuit targeted for SOG**	**Work Order - N** **Job Plan =** SGSELFHEAL **Related Record** Ref Type=SOG, Value=ckt#	**Specific Project ID** When creating WO's, a specific project may be generated requiring approval.	**Specific Project ID** When creating WO's, a specific project may be generated requiring approval.	**Capacity Planning:** Communication to Transmission organization to initiate work. All W.O. creation, design and construction performed by Transmission. **Grid Solutions:** Monitoring of job status via SOG program management reporting.
	Work Order – N+1 **Job Plan =** SGSELFHEAL **Related Record** Ref Type=SOG, Value=ckt#	**Work Order - N** **Job Plan =** SGUPGDISTLINE **Related Record** Ref Type=SOG, Value=ckt#	**Work Order - N** **Job Plan =** SGFEEDERCAP **Related Record** Ref Type=SOG, Value=ckt#	
	Work Order – N+2 **Job Plan =** SGSELFHEAL **Related Record** Ref Type=SOG, Value=ckt#	**Work Order – N+1** **Job Plan =** SGUPGDISTLINE **Related Record** Ref Type=SOG, Value=ckt#	**Work Order – N+1** **Job Plan =** SGFEEDERCAP **Related Record** Ref Type=SOG, Value=ckt#	
	Work Order – N+3 **Job Plan =** SGSELFHEAL **Related Record** Ref Type=SOG, Value=ckt#	**Work Order – N+2** **Job Plan =** SGUPGDISTLINE **Related Record** Ref Type=SOG, Value=ckt#	**Work Order – N+2** **Job Plan =** SGFEEDERCAP **Related Record** Ref Type=SOG, Value=ckt#	

Work Order Creation Job Aid SOG WO Creation Job Aid Rev 0.docx **Mass Work Order Creation Tool Job Aid** Mass Work Order Creation Job Aid.doc

4.0 S.O.G. Work Order Description Naming Convention

4.1 S.O.G. Circuit Kickoff (Shell) WO Naming Convention - this Naming Convention is for the Kickoff (Shell) work order that will define SOG circuit scope of work.

➢ **Circuit Kickoff (Shell) Naming Convention**

GIP_SOG_Feeder Number_BACKBONE

- Example: GIP_SOG_T4600B04_BACKBONE
    - SOG work for circuit T4600B04

➢ **I&C Tech/ Equipment Operator Site Evaluation Naming Convention**

GIP_ASD_Feeder Number_BACKBONE _ SITE EVAL_DIS#/Field Tag ID or Lat.,Long.

- Example: GIP_ASD_T4600B04_BACKBONE_ SITE EVAL_ 1DDQ93 or 35.1234,73.456

4.2 Individual Work Orders Under Annually Funded Work Stream (AFWS)

➢ **Automated Switching Device (ASD) Naming Convention (Typically Electronic Reclosers)**

GIP_ASD_(Feeder Number)_BACKBONE_(Field Tag ID or Lat.,Long.)

- Example: GIP_ASD_T4600B04_BACKBONE_1DDQ93 or 35.1234,73.456

➢ **Open Point Recloser/ASD Naming Convention**

GIP_ASD_(Feeder Number)_BACKBONE_(Field Tag ID or Lat.,Long.)_Open Point

- Example: GIP_ASD_T4600B04_BACKBONE_1DDQ93 or 35.1234,73.456_ Open Point

➢ **Circuit Capacity Naming Convention**

GIP _CAP_(Feeder Number)_BACKBONE_(Description and Funding Project ID(if desired))

- Example: GIP_CAP_T4600B04_BACKBONE_N Oak Ave to E Lebanon then Briarclift Rd to Saddle Club Rd

➢ **Substation Capacity Naming Convention**

Transmission Generated

➢ **Connectivity Naming Convention**

GIP _CON_(Feeder Number)_BACKBONE_(Description and Funding Project ID(if desired))

- Example: GIP_CON_T4600B04_BACKBONE_N Oak Ave to E Lebanon then Briarclift Rd to Saddle Club Rd

➢ **Conductor Ampacity Upgrades (driven by new conductor ratings and not SOG)**

GIP _CUPG_(Feeder Number)_BACKBONE_(Description and Funding Project ID(if desired))

- Example: GIP_CUPG_T4600B04_BACKBONE_N Oak Ave to E Lebanon then Briarclift Rd to Saddle Club Rd

5.0 Enterprise Self Optimizing Grid Strategic Program Charging Guide:

Annually Funded Work Stream (AFWS)	Job Plan	Description
Automation & Self Healing	SGSELFHEAL DEF-SGSELFHEALF DEC-SGSELFHEALC DEP-SGSELFHEALC DEO-SGSELFHEALOK DEK-SGSELFHEALOK	This work stream involves installing DSCADA-enabled electronic reclosers on the backbone for segmentation purposes. Recall the design criteria of segmenting the backbone is an average of 400 customers, 3 miles of circuit or 2MW of load. Normally-open reclosers for circuit ties will also be charged to this Job Plan. The Job Plan starts with **SGSELFHEAL** and ends with a unique code for each jurisdiction. Note the change from Specific to a Blanket charging mechanism since the average work request cost for a recloser is generally less than $50,000. Also, all work associated with Self-Healing modeling and testing will be charged to the jurisdiction blankets.
Capacity	SGFEEDERCAP	Circuit Capacity - Projects to increase Circuit Capacity as a result of meeting SOG restoration targets.
	SGAMPACITYUPG (Not SOG Driven)	Conductor Ampacity Upgrades - This effort involves upgrading conductors utilizing the common rating standards now used enterprise-wide.
	SGSYSCAPACT	Substation Capacity - Projects to increase substation capacity as a result of meeting SOG restoration targets. This “inside-the-fence” effort could involve transformer bank increases, new circuit breakers or new substations.
Connectivity (excludes tie device)	SGUPGDISTLINE	Projects to build circuit ties to alternate sources which will allow for reconfiguration options when sustained faults occur. Note the normally-open recloser will be designed under the Automation and Self-Healing AFWS .

Section IV - Circuits not Qualifying for Self Optimizing Grid

Background: Based on estimates, 20% of our customers are on the remaining 40% of our distribution circuits not targeted for full implementation for Self Optimizing Grid. These circuits either do not have enough customers on the circuit or do not have a feasible means for inter-circuit connectivity with an alternate source. These remaining circuits will still be segmented with automated switching devices and utilized by Closed Loop FISR. Work on these circuits will take place in the latter years of the Grid Improvement Plan. This section is intended serve as a guide for what should be done on these circuits.

Segmentation – Apply the segmentation rules of Section II

Connectivity (Circuit Ties) –

- The installation of new circuit ties are not required under the Self Optimizing Grid program for non-qualifying circuits. Based on engineering judgment, if a new circuit tie is deemed necessary, the cost should be covered under the Reliability and Integrity Programs in the Grid Improvement Plan. New construction circuit tie work should <u>not</u> be charged to Self Optimizing Grid for non-qualifying circuits.
- Utilize an existing circuit tie only if the conductor on both sides of the tie is 1/0 ACSR or greater.
- Do not upgrade conductors as part of utilizing a circuit tie. Closed Loop FISR (CL FISR) bases restoration decisions on real time load flow circuit models and therefore should not utilize a tie if doing so results in an overload and voltage violation situation.
- Any utilized circuit tie must have a SCADA enabled and controllable device.

Capacity – Does not apply. Existing radial circuits should have adequate capacity. In the event that an automated switch is placed at a circuit tie, Closed Loop FISR will determine the feasibility of automatic restoration and will operate only if doing so does not create an overload or a voltage violation situation.

Automation – Apply the automation rules in Section II

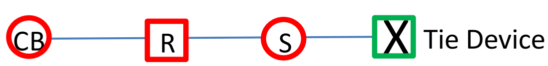
Section V: Self Optimizing Grid Segmentation Device Mode of Operation Guide

General Recommendations: Applies to the feeder backbone of each circuit part of Self Optimizing Grid

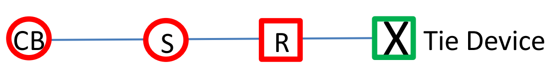
- There will be only one segmentation device setup as a recloser on the feeder backbone. This recloser should be somewhere close to midpoint based on customer count. Use judgment as to which device is setup as the recloser based on circuit characteristics such as large customers or outage probability. There will be reasons in some jurisdictions for which the recloser needs to be closer to the substation due to fault current levels and breaker reach. Exception: If needed to address a reach issue, two reclosers in series is acceptable. Setting up two segmentation devices as reclosers is expected if the circuit has a major load split close to the substation (device setup as a recloser on both sides of the split).
- Any first device downstream of the circuit breaker or the recloser should be setup as a sectionalizer.
- Any second, third, nth device downstream of a breaker or recloser should be setup as a switch. No series sectionalizer between the breaker and the recloser or between the recloser and the tie point. Some jurisdictions have three operations to lockout on breakers and reclosers. As a result, from an enterprise perspective, two sectionalizers cannot be placed in series directly behind the same reclosing device (open point excluded). The number of counts for sectionalizers is a jurisdictional decision. Note: Use judgment as to which device is setup as a sectionalizer based on circuit characteristics such as large customers or outage probability.
- Tie point device can be setup as desired based on jurisdictional preferences.

Theoretical Circuits CB Circuit Breaker S Sectionalizer R Recloser Sw Switch

2 Segmentation Devices



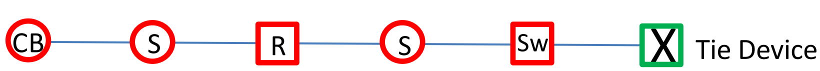
Preferred – Lower MAIFI with single phase trip. Better breaker reach for some jurisdictions.



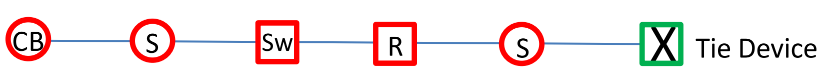
Alternate – May allow larger customers to be upstream of the recloser for fewer blinks.

3 Segmentation Devices

4 Segmentation Devices

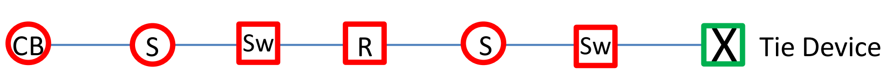


Preferred – Lower MAIFI with single phase trip. Better breaker reach for some jurisdictions.



Alternate – May allow larger customers to be upstream of the recloser for fewer blinks.

5 Segmentation Devices



Appendix I - Questions and Answers: This section is intended to provide further clarification on this application guide based on submitted questions.

SOG Analysis and Capacity Related

Question: How does SOG affect existing extra facilities such as a customer paying for an alternate feed with reserve capacity?
Answer: There two angles to this question. If a customer is paying extra facilities for an alternate feeder, this means they are paying for the automatic throw-over and reserve capacity. SOG is not intended to serve as a replacement since there is no guarantee that restoration will take place to all unfaulted line segments as intended. Pre-existing ATO's and the input feeders should not be altered by SOG unless the contract has expired and the customer chooses not to renew. Also, the reserve capacity must be factored in when considering capacity requirements for SOG.

Question: When considering the 75% of projected peak rule for unloading to relief circuits, does that apply to the bank as well? For example, look at the peak load at the relief bank and assume you will be picking up the extra load when the bank is at 75% of its peak.
Answer: Assume the relief bank is at 75% of peak demand as well. Designing capacity to handle additional circuit load at 75% of peak, while considering the bank load at 100% of peak could lead to unintended bank upgrades.

Question: When considering the 2MW segment load target, should that load also be considered at 75% of peak load.
Answer: Yes. All load considerations under SOG should be taken at 75% of projected peak to meet the 90% of the hours in a given year availability rule.

Question: Do we consider load growth while performing SOG circuit analysis.
Answer: In general, do not include load growth. If there is a circuit with or expecting a much higher than normal load growth, this can be considered as part of the circuit analysis. When executing load growth projects, the project should be built to SOG rules. Segmentation device installations as part of this project can be charged to SOG.

Question: Post SOG circuit work, how far is the capacity allowed to be eroded due to load growth before action is taken to regain the original availability target of 90% of hours per year? Do we allow large customers adds without work to redesign the segment or add capacity to meet the original SOG design?
Answer: The original intent was that the business will maintain SOG to original design, post deployment. However, there have been no set rules around when and how this happens. More work is needed to address this question.

Question: If a SOG feeder has multiple ties, should we stop our review when we can unload the SOG feeder at 75 % peak even if that means several ties were not reviewed. If there is a feeder tie that is not selected to be part of the SOG network, should we install an automatic switching device at the unused tie point?
Answer: If there is another feeder tie that is above what is necessary to unload a SOG circuit, engineering judge should be utilized to weigh the benefit of the additional tie. If this additional tie helps to unload a SOG circuit, adds additional switching options, and the conductor is greater than #2 ACSR, the installation of this additional tie is acceptable. Do not install non-essential ties until SOG work is planned on the alternate (relief) circuit. If the tie is between 2 non-SOG circuits, installing an ASD must be funded from a different bucket of money.

Question: How far do we go into the alternate (relief) circuit with SOG principles? SOG the entire circuit?
Answer: If the circuit is in the 10 year SOG plan, analyze the alternate (relief) circuit for connectivity, capacity and automation. If the circuit is not in the 10 year plan, only apply the automation (segmentation) rules. Exception: If the relief circuit is not on the SOG list, but is the only alternate source for circuit part of SOG, the relief circuit should be included in SOG also. In the either case, stop work on the alternate (relief) circuit at circuit ties to a third circuit, i.e. don't add ASD's at tie points on circuits beyond the relief circuit until the scheduled SOG analysis on those circuits.

Question: How should we model capacitor banks for voltage support when performing a SOG circuit analysis?
Answer: Assume that all switched bank capacitors are on.

Question: What conductor ratings should be used in the model?
Answer: Refer to the new conductor ratings published in the enterprise Distribution Standards manual. Per the listed notes below the ampacity chart, legacy ratings can continue to be used on lines constructed before the 2016 publication as long as the legacy ampacity rating was based on a conductor temperature of 185F or less. Legacy ampacity ratings that were based on a conductor temperature greater than 185F are now required to utilize the published enterprise ratings, which includes DEC. There are no longer emergency ratings.

Question: Do we design SOG such that we have bank failure contingency, i.e. be able to pick up the entire load of the bank if there is a failure.
Answer: Although it is desired to have the ability to pick up as much load as possible in most circumstances, requiring a bank failure contingency would lead to the need to upgrade a lot of banks for a very low risk event. Therefore, SOG should be designed for a single circuit contingency.

Question: What are the rules concerning "utilized" circuit ties for a tie in a loop on the same circuit?
Answer: While there may be some benefit, a circuit tie ASD in a loop on the same circuit does not provide benefit if losing most or all a circuit during an event. As a result, it is not a recommended practice. However, if the additional tie allows adherence to the rule of isolating a fault to one segment, while restoring all other customers, this would be allowed. Use engineering judgment.

Question: What are the rules around DER with respect to SOG?

Answer: A general recommendation is to exclude circuits with DER for the first couple of years of the program if possible. The current self healing system software, YFA, can model DER. However, this system does not control regulators, which presents an issue when an upstream line regulator controller is locked on CoGen mode and the regulator is back-fed from a new stiff source. Essentially, the regulator can go into runaway either stepping to max buck or boost. Below are further recommendations per jurisdiction.

DEMW – Include DER as desired. The Midwest uses the M-6200 regulator control that has an auto determination feature eliminating the runaway concern.

DEC – If there is no upstream line regulator(exclude circuit exit regulators), DER can be integrated as desired. If there is an upstream line regulator, avoid if possible. If there is a strong desire to include immediately, a control change-out will be necessary. Contact Rod Hallman.

DEP - If there is no upstream line regulator(exclude circuit exit regulators), DER can be integrated as desired. If there is an upstream line regulator, avoid if possible. A control change-out to prevent the concern is not possible until the full DMS conversion to Alstom.

DEF - If there is no upstream line regulator(exclude circuit exit regulators), DER can be integrated as desired. If there is an upstream line regulator, avoid if possible. If there is a strong desire to include immediately, a control change-out will be necessary. Contact Rod Hallman.

Load Limits and Protection Settings

Question: Is there a plan to coordinate determining protection settings and recloser mode?

Answer: Enterprise-wide, who determines the settings that are put in the reclosers and even how they are setup (recloser, sectionalizer or switch) are not the same. In DEF, DEI, DEO and DEK this is determined by the capacity planners. In the Midwest, these recommendations are installed through DPAC. In the Carolinas, although the capacity planners may look at reach and recommend how they think the device should be setup, determining the protection settings and the device mode is ultimately a DPAC decision. The implementation of SOG was not meant to and should not change this current process of determining reach or protection settings. Recently, an enterprise guide for determining the recloser mode/setup (also called mode of operation) was established and should be used. See Section V. In all jurisdictions, the planner has some level of involvement and should keep in mind the downstream customer type in making recommendations on the setup. For example, if there are multiple ASD's and a larger customer exists close the midpoint, it may be better to setup the first ASD downstream from this customer as a recloser to reduce momentary operations seen by this customer.

Question: Existing SH rule in DEC concerning setting load limits is set with respect to equipment ratings or no higher than 75% of the trip settings of the protective devices in an effort not to cause another lockout. How does SOG affect this?

Answer: Load limits on individual devices are Cooper YFA specific. How they are determined and who makes the determination is a little different across the company. For example, load limits in DEF may be set based on expected conductor sag rather than on equipment ratings and trip protective settings due to tight clearances and larger conductors. SOG should not change the current process for determining load limit or protection settings. Once FISR is in place, load limits settings per device will no longer be needed.