Carnegie Mellon

Electric Energy | EESG | Systems Group

Electrical & Computer ENGINEERING

Reconfiguration of Distribution Network for Differentiated Reliability of Service

Siripha Junlakarn: sjunlaka@andrew.cmu.edu

Jovan Ilic : jilic@cmu.edu

Marija Ilic: milic@ece.cmu.edu

The 8TH Annual Carnegie Mellon Conference on the Electricity Industry

March 12, 2012

Outline

Background

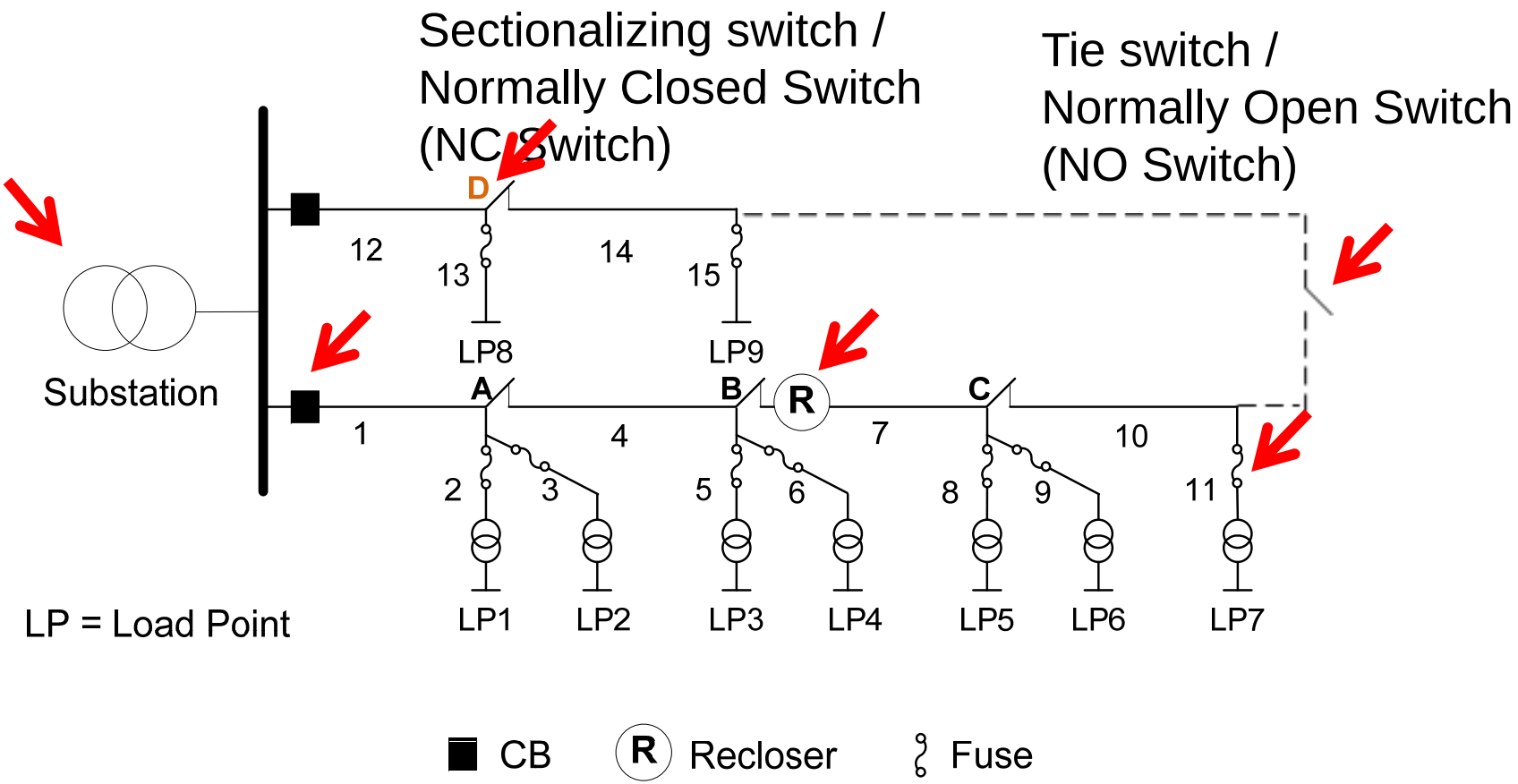
Problems and Methods

Results

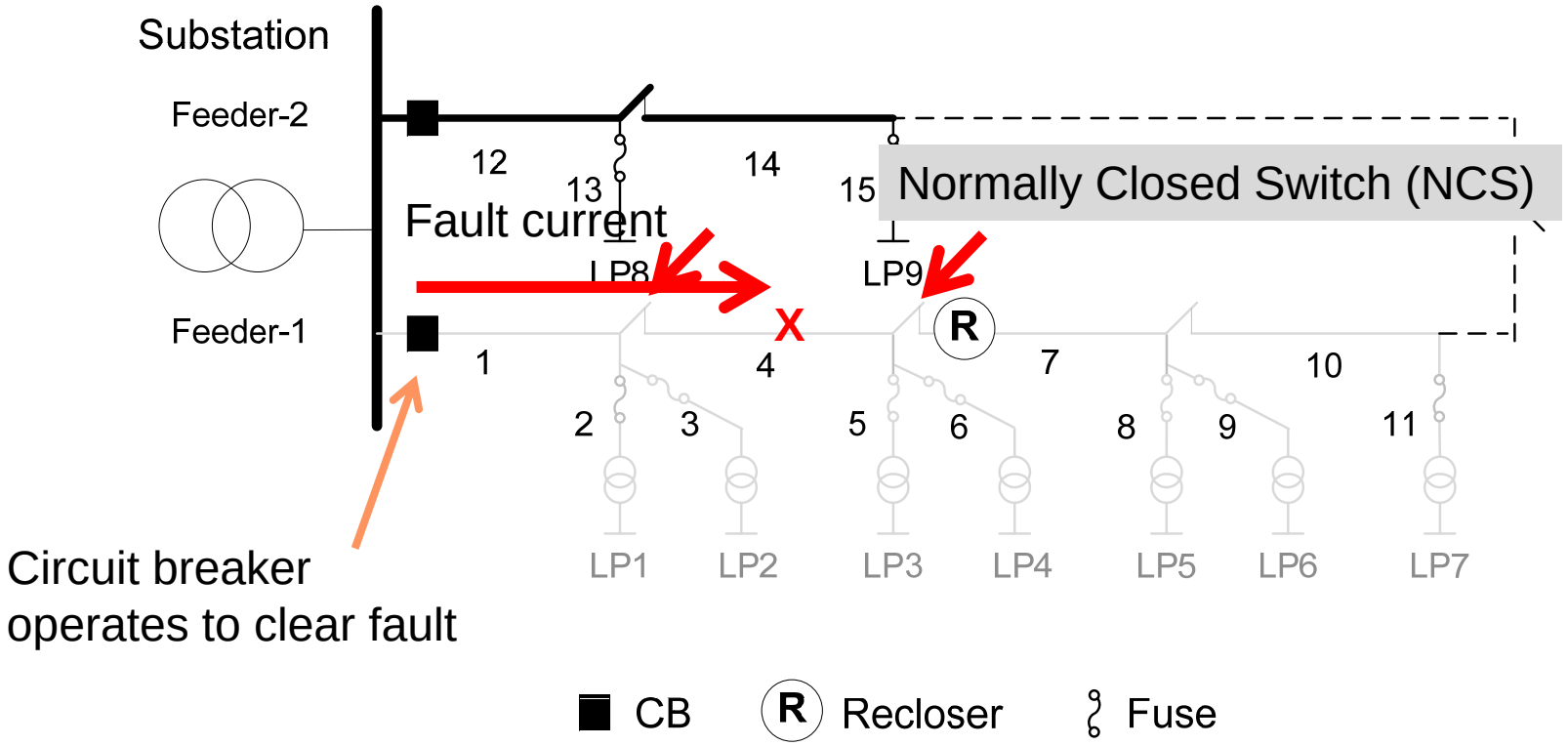
Background

- **The idea**: the reconfiguration in distribution network to create reliability choices for different customers
- **Reconfiguration**: close and open Normally Closed Switches (NCSs) /Normally Open Switches (NOSs) during equipment outages to minimize utility liability
- **Reconfiguration and DG**: Use both to create reliability choices
    - **Power supply is sufficient for all customers**: a configuration that supplies power to as many customers as possible
    - **DG is the only power supply**: a configuration that distributes power to priority customers

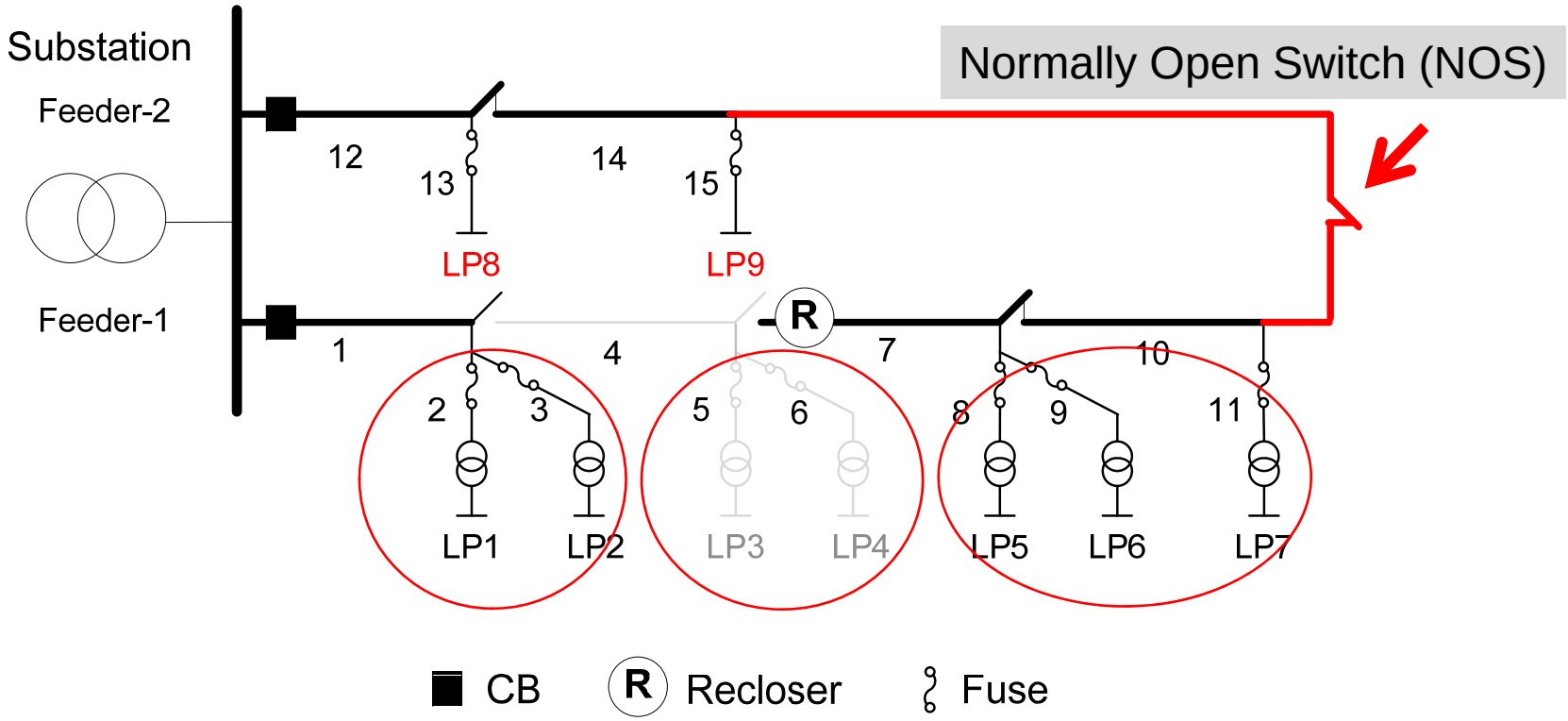
Today's protection in distribution networks



Possible reliability enhancements using NCSs and NOSs in today's distribution networks (no DGs)



The resulting reliability improvement



Problem and Methods

Results

Today's reliability of distribution networks

- Today, distribution system is designed to meet "minimal" socially acceptable reliability
- **End-users:**
    - Industrial/commercial customers want "high" reliability
    - Residential customers may not want reliability as much as the system provides now

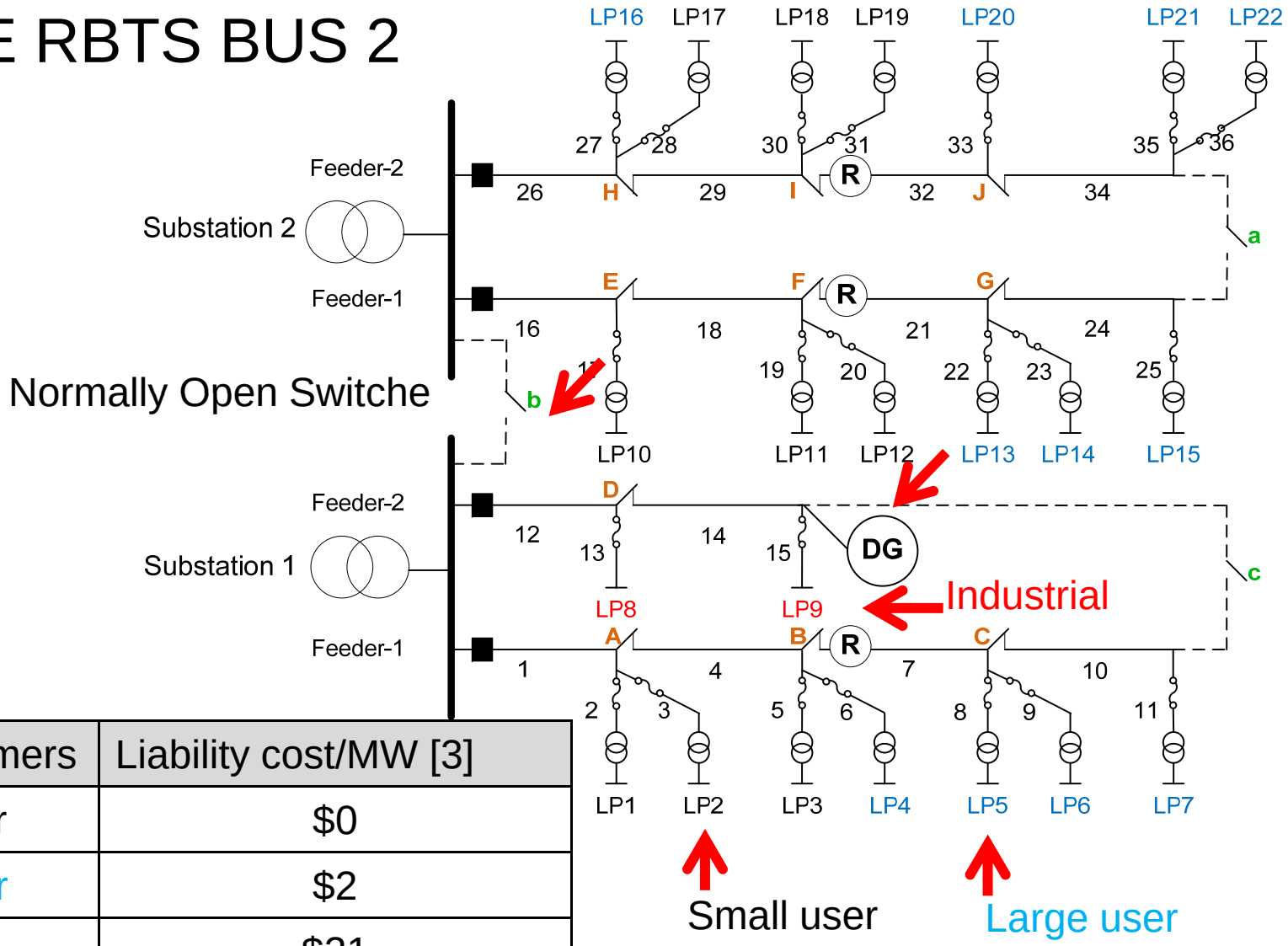
How to create reliability choices in a distribution network?

- **Supposed that:** a utility provides differentiated reliability options for customers to choose from
- A Utility would guarantee that these customers would be supplied according to their agreement
- A Utility will compensate customers if it fails to supply power
  - This compensation is defined as the **utility's "liability cost"**

Methods

- Find a methodology for a utility to provide reliability choices to all customers
- Tools for creating reliability choices
    - Normally Closed/Normally Open Switches (NCSs/NOSs): reconfigure the system
    - DG: as power back-up when losing connectivity of all substations
- **Output:** Combinations of NC/NO Switches

IEEE RBTS BUS 2



Type of customers	Liability cost/MW [3]
Small user	$0
Large user	$2
Industrial	$21

[3] In-Su Bae; Jin-O Kim; Jae-Chul Kim; Singh, C. Optimal operating strategy for distributed generation considering hourly reliability worth. I*EEE Transactions on Power Systems*, 2004

Offline search for optimal configuration

- Formulate the problem as an optimization problem
- The algorithm attempts to **minimize the total liability cost the entire distribution system when a fault occurs for one hour**

$$\min \sum_{i=1}^{No.\ of\ Load\ Point} Liability\ Cost_i \times P_{not\ supplied,i}$$

- One possible method is using genetic algorithms, whose proof-of-concept was shown in [1,2] for small systems

[1] S. Junlakarn, "Optimal sizing of distributed generators in consideration of impacts on protection coordination using genetic algorithms," *M.S. thesis*, Chulalongkorn University, Thailand, 2006
[2] S. Junlakarn; N. Hoonchareon, Optimal sizing of distributed generators in consideration of impacts on protection coordination using genetic algorithms," *Proceedings of 30th Electrical Engineering Conference*, Thailand, Vol. 1, pp. 109-112, Oct 2007

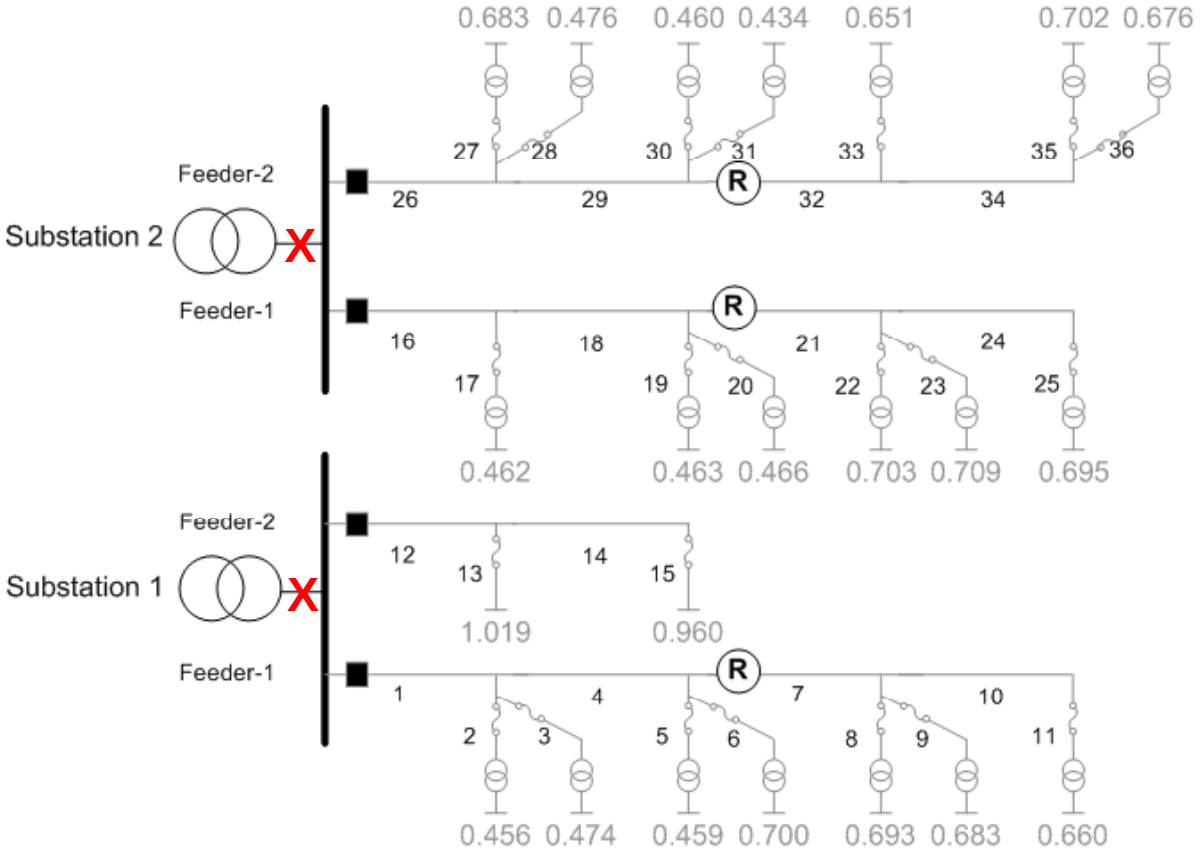
Problem and Methods

Results

Faults at both substations

- Base case (no Normally Closed and Normally Open switches and DG)
- Sufficient DG
- Limit DG

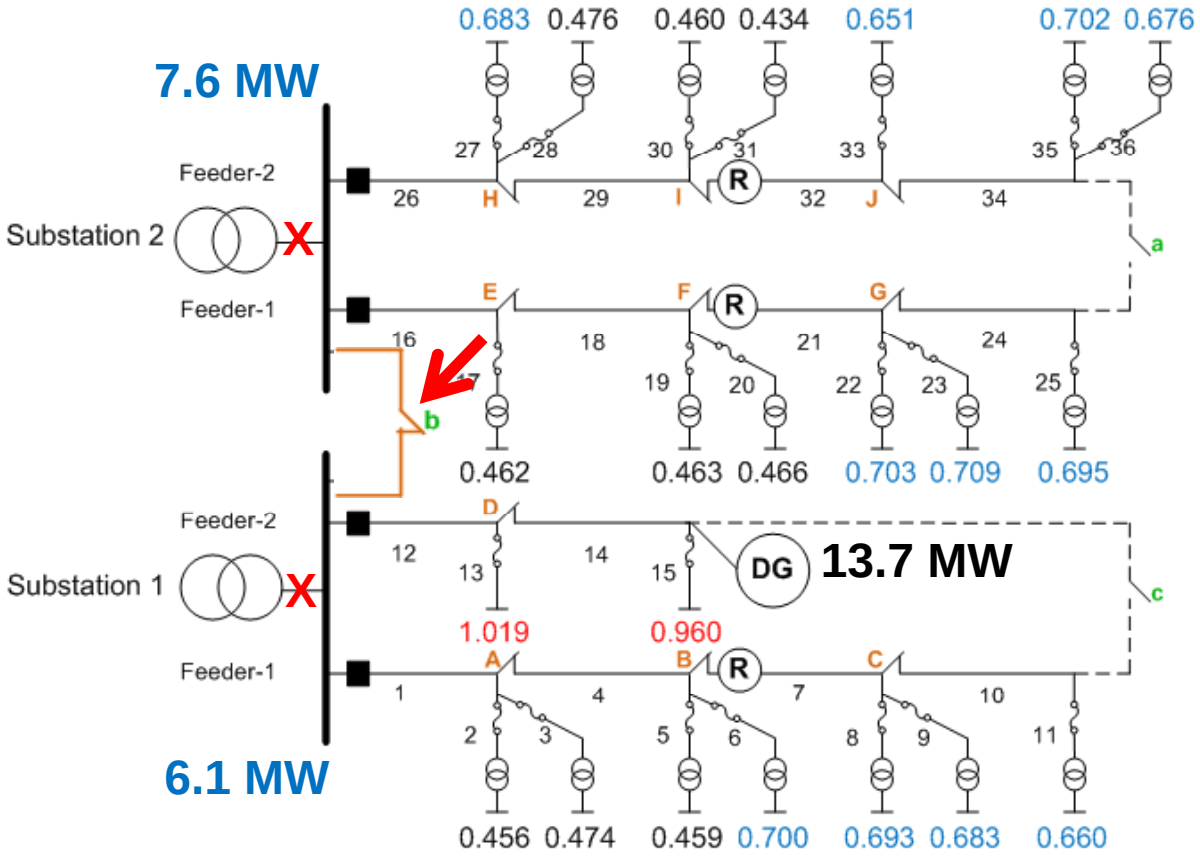
Faults at Both Substations: Base case



- Small user:
  - 4.15 MW
- Large user
  - 7.56 MW
- Industrial
  - 1.98 MW

Fault occurs in 1 hour	Base case	Sufficient DG	Limit DG
Total of liability cost	$56.7		

Faults at Both Substations: Sufficient DG

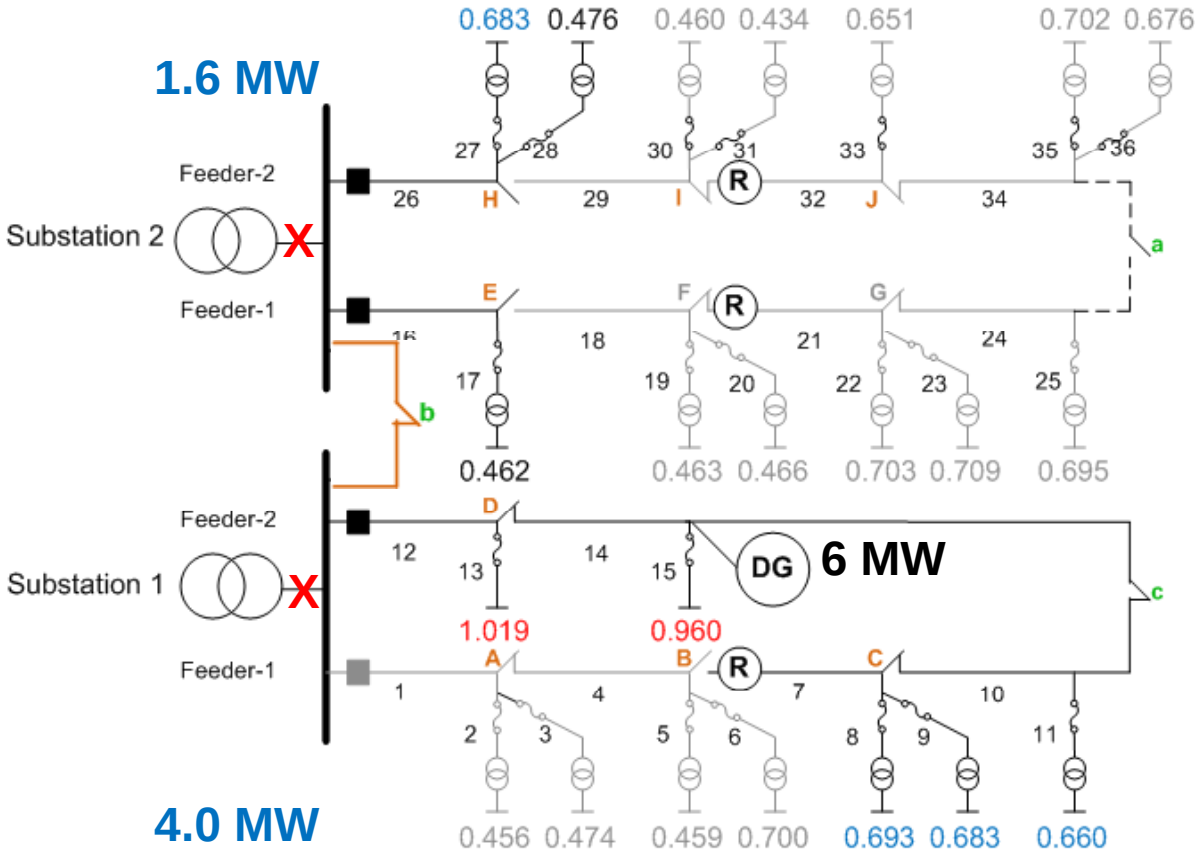


Switch Set

- NOS-b closes
- DG can supply power

Fault occurs in 1 hour	Base case	Sufficient DG	Limit DG
Total of liability cost	$56.7	$0	

Faults at Both Substations: Limit DG



Switch Set

- CB, NCS-B, NCS-E, NCS-H open
- NOS-b, NOS-c close
- DG can supply power

Fault occurs in 1 hour	Base case	Sufficient DG	Limit DG
Total of liability cost	$56.5	$0	$9.7

Conclusion

- Reconfiguration and DG to provide differentiated reliability
- Customer would be provided with a reliability that they want, and would not be forced to pay for reliability that they value less.
- Further research on how to implement this methodology

Q &A