

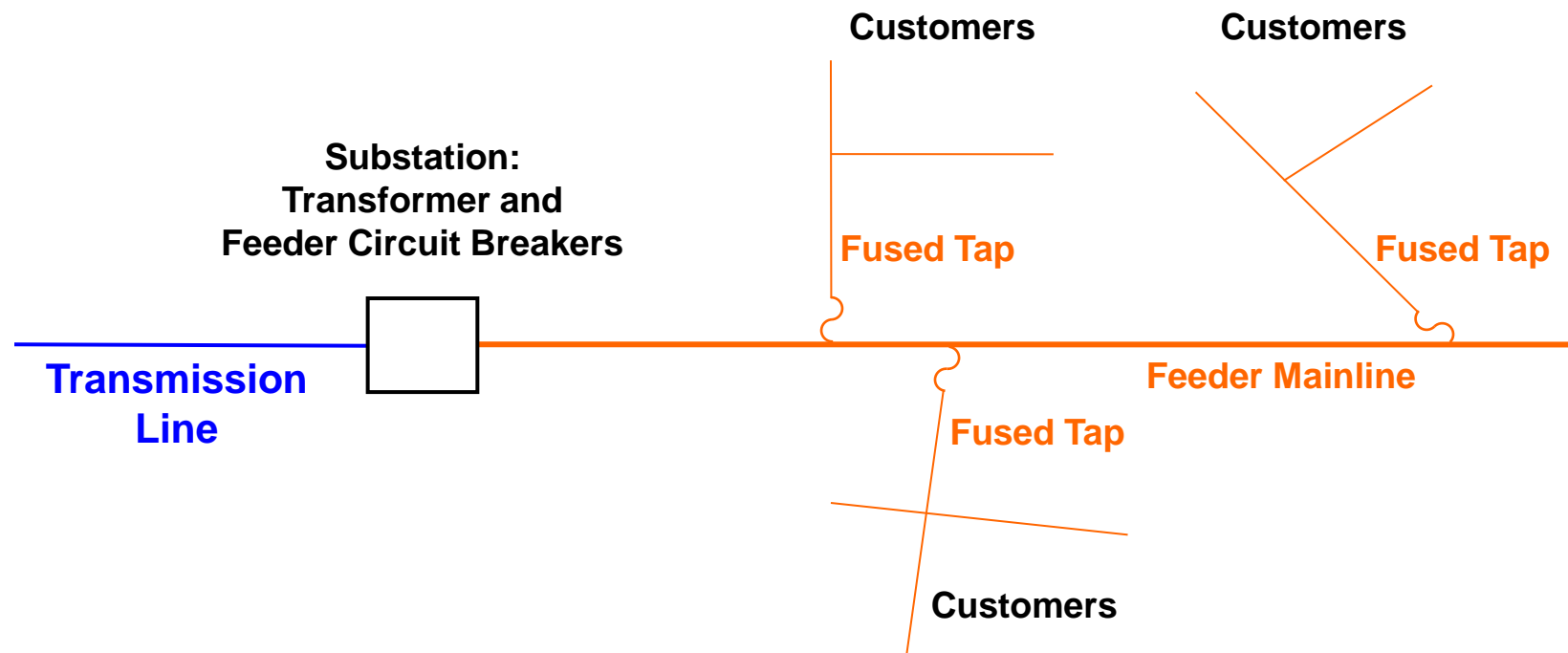
Distribution System Modernization

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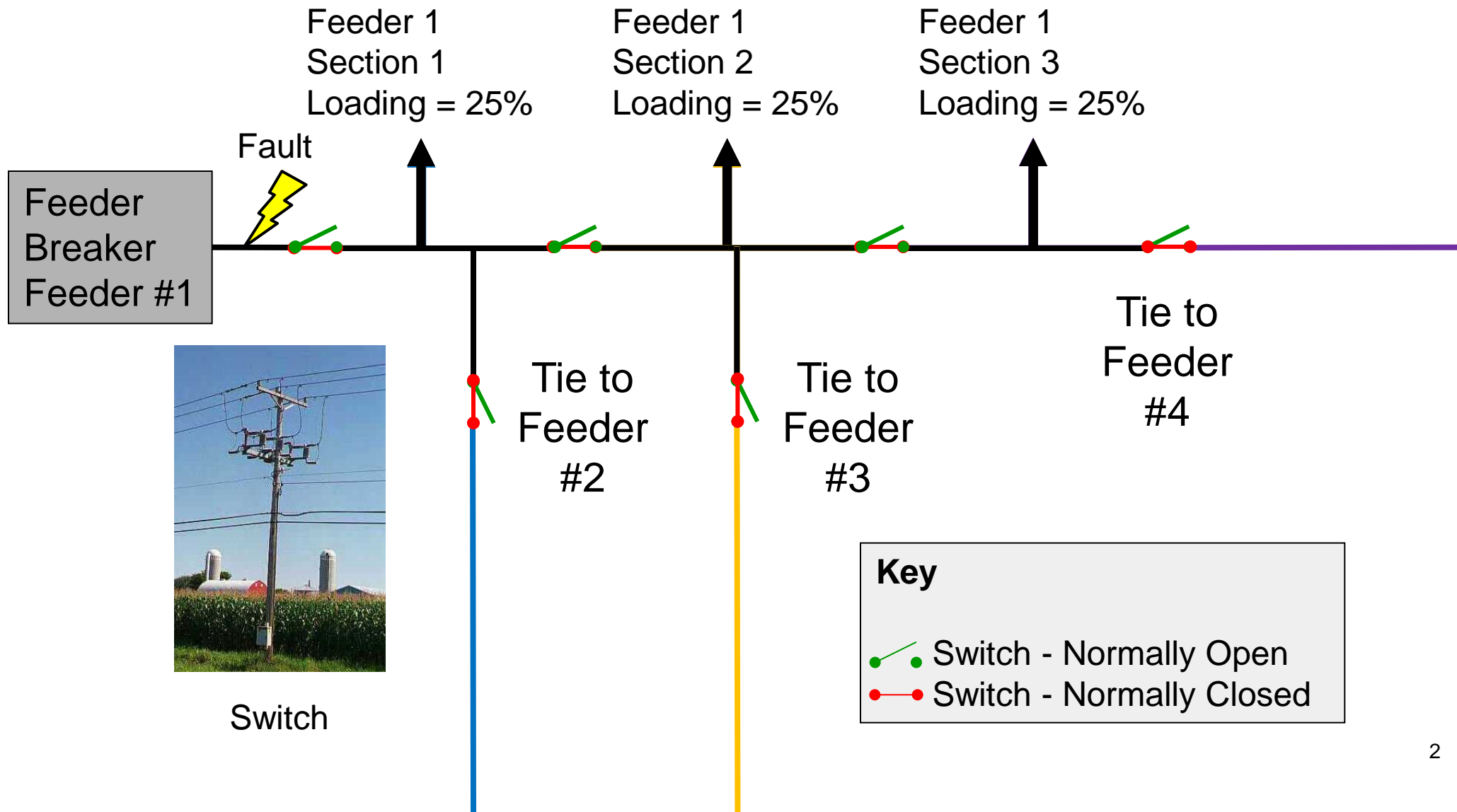
Distribution System: Basic Design

Schematic of Typical Radial Circuit Design



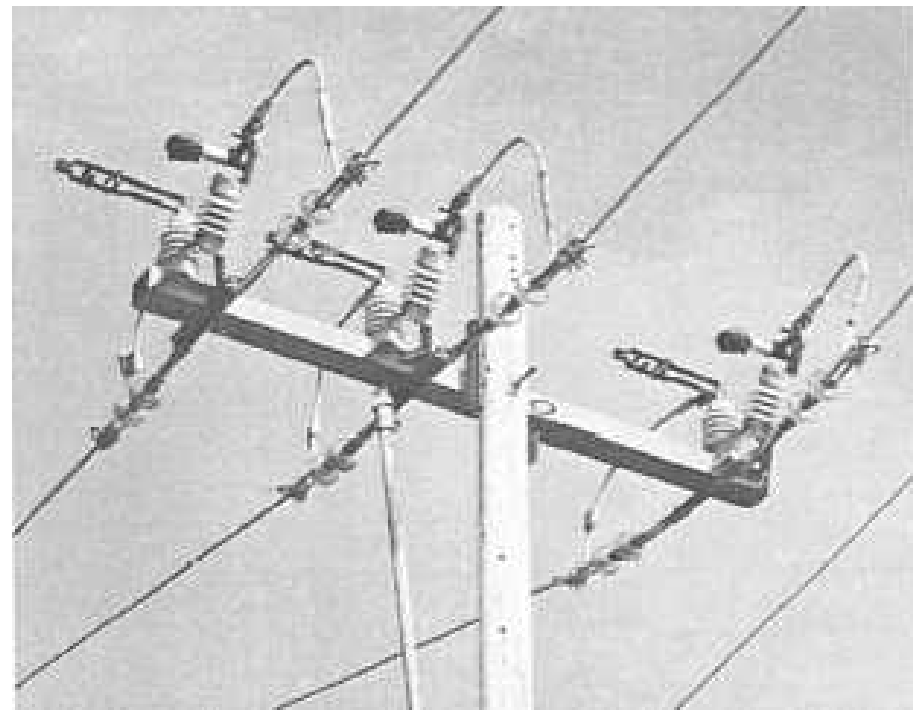
Designed for Safety and Reliability

Reliable Feeder Design



Modernization – Why Now?

- Technology on and for the grid is rapidly changing
- Unprecedented changes in the industry
- Customer experience and customer choice is more important than ever

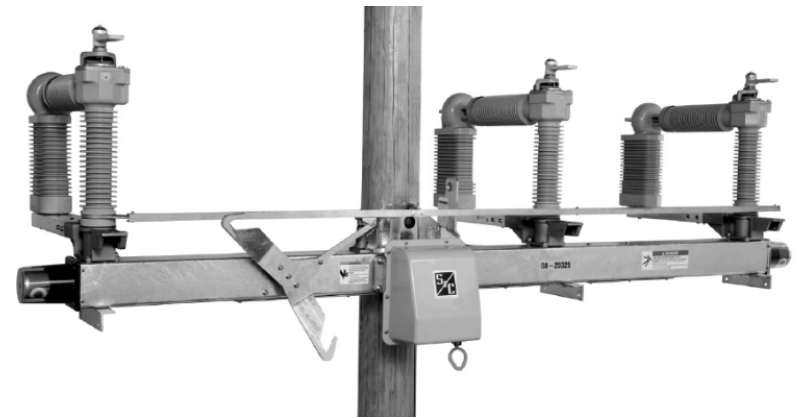


Distribution System Planning for the Future

- Forecasting quantity and dependability of DG
- Forecasting impacts of conservation & load control
- Forecasting electric vehicle adoption
- Move from “peak only” forecasting to 24/7
- Improve planning & forecasting tools
- Consider storage implications

Modernization

- **Refreshing Existing Assets**
 - Refreshing aging assets
 - Improving performance & efficiency
- **Distribution Automation**
 - Intelligent capacitor control
 - Feeder automation
 - Advanced fault locating
 - ~2,000 DA devices in MN
- **Preparing to integrate DER & enjoy technological advances**



Preparing for a more Intelligent Distribution System

- **Distribution System Intelligence**
 - ◆ **Advanced Distribution Management System**
 - ◆ **Secure Field Area Network**
 - ◆ **Expand SCADA coverage**
 - ◆ **Advanced Field Devices**
 - ◆ **Monitoring & Control Equipment**
 - ◆ **Capacitor Controls**
 - ◆ **Smart inverters**
 - ◆ **Automated field switches (FLISR)**
 - ◆ **Dispatchable Resources (DG, Storage, DER)**

Smart Inverters

- **What is a smart inverter?**
 - **Communicates two-ways**
 - **Better control of intermittent generation**
 - **Ability to stabilize rather than contribute to voltage problems on the grid**
 - **Provides owner with asset performance data**

- **Industry is moving towards a Smart Inverter requirement**
- **Next step is to integrate control of Smart Inverters with a central system to further improve feeder performance**
- **Greater control allows for higher penetrations of DER**



Building Blocks

Analytical Tools		Dynamic Power Flow	HAN (Home Area Network)		<p>Enabled Applications</p>	2017-2023
Micro Grids	EVs (Electric Vehicles)	Energy Storage	Operational Efficiency			

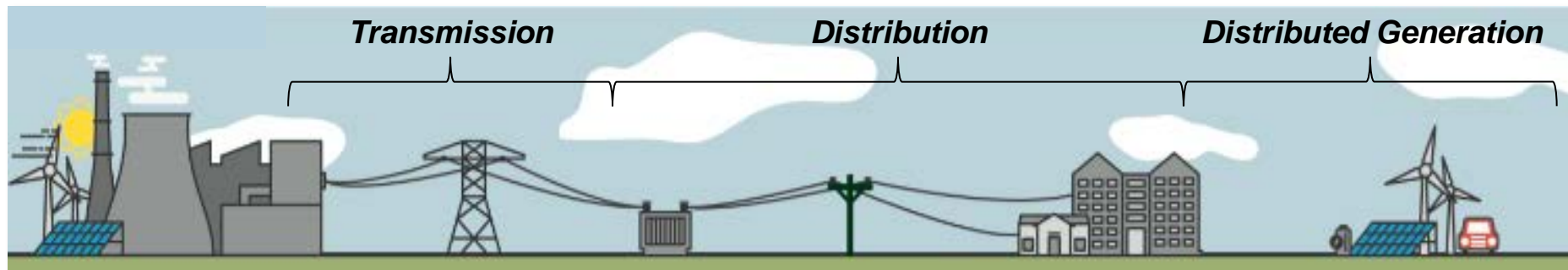
DER (Distributed Energy Resources)	DA IVVO FLISR	Advanced Metering Infrastructure	Substation Automation	<p>Fundamental Applications</p>	2013-2020

OMS		ADMS		D-SCADA		Field Devices		<p>Foundational Elements</p>	2012-2018
						Controls	Sensors		
GIS	IT Infrastructure		Communications Infrastructure		Feeder Topology		Asset Management Framework		

Conclusion

- **We face a challenge of funding capacity needs, asset refreshment, and modernization – finding the right balance**
- **Distribution planning is becoming more complex**
- **The integrated grid of the future will be robust & reliable, serving energy users and producers alike**

Questions?



ACRONYMS AND DEFINITIONS

Abbreviation	Definition
CAIDI	C ustomer A verage I nterruption D uration I ndex: Measures the average outage duration of an interruption divided by the number of customer interrupted. CAIDI is also equal to SAIDI / SAIFI.
Circuit Breaker	An electromechanical device used to configure the flow of electricity on the distribution grid. A Circuit Breaker is designed to open or close while electricity is flowing through the circuit. When a circuit breaker is open, no electricity is flowing through the circuit
Fault	A condition typically in which a feeder or tap is overloaded creating a risk of fire or explosion
Feeder	Lines connecting distribution substations to taps
Firm	Capacity or generation that can be counted on to be available at all times and ready to serve in backup contingency situations
kVA	Kilo Volt Amps: 1,000 Volt-Amps. A volt is a measure of the force of electricity. An amp (ampere) is a measure of the flow of electricity
MAIFI	M omentary A verage I nterruption F requency I ndex: Measures the average number of momentary interruptions for the average customer over a given period (usually monthly or annually)
MVA	Mega Volt Amps: 1,000,000 Amps or 1,000 kVA

Abbreviation	Definition
Recloser	A circuit breaker that includes a mechanism to automatically close (reconnect) after a set period of time. Reclosers are used to restore service after a momentary fault
SAIDI	System Average Interruption Duration Index: Measures the total duration of an interruption for the average customer for a given period (usually monthly or annually). Lower values are better.
SAIFI	System Average Interruption Frequency Index: Measures the average number of times a customer is interrupted over a given period (usually monthly or a annually). Lower values are better.
Switch	An electromechanical device used to configure the flow of electricity on the distribution grid. A switch is designed to be opened or closed when electricity is not flowing through the circuit. When a switch is open, no electricity is flowing through the circuit
Tap	Final leg of the distribution system before connecting to customer premises
Transformer	An electromechanical device that converts alternating current to higher or lower voltage