



# SUBSTATION TOPOLOGY PLANNING FOR RELIABILITY

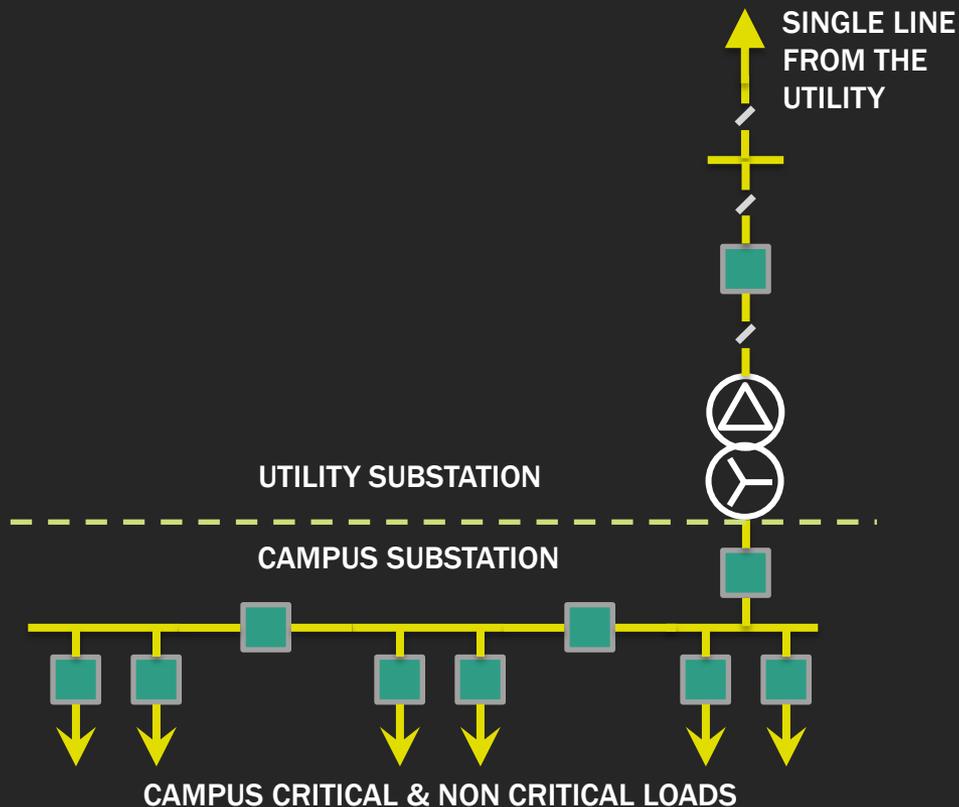
Roger Copeland, PE | Kalai Uthirapathy, CEng

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Typically, you can only improve what you control.

How can we optimize **reliability and resiliency** when we are served by outside utilities? What are the costs and benefits?

# TYPICAL ELECTRICAL SYSTEM

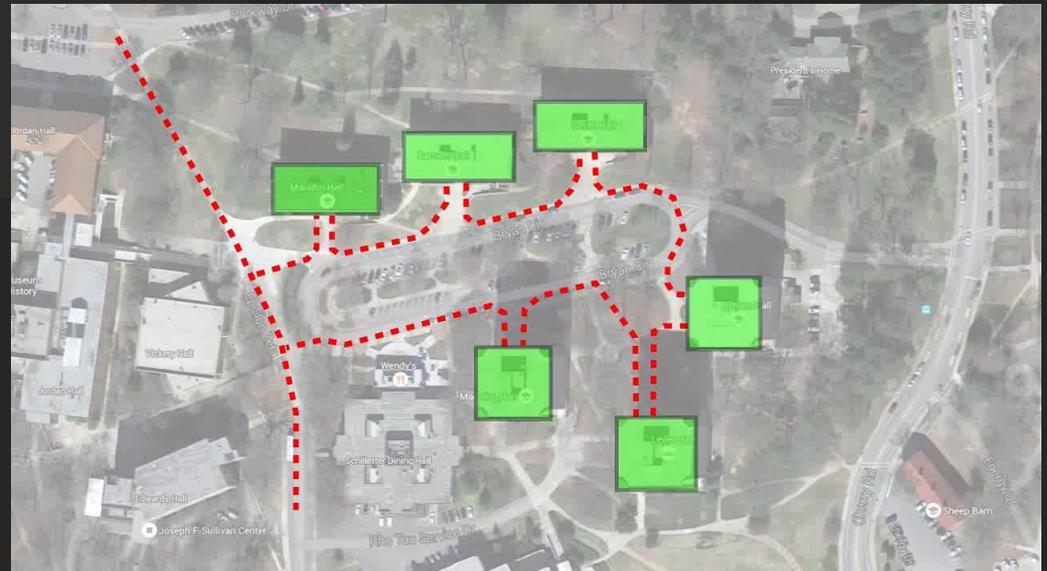
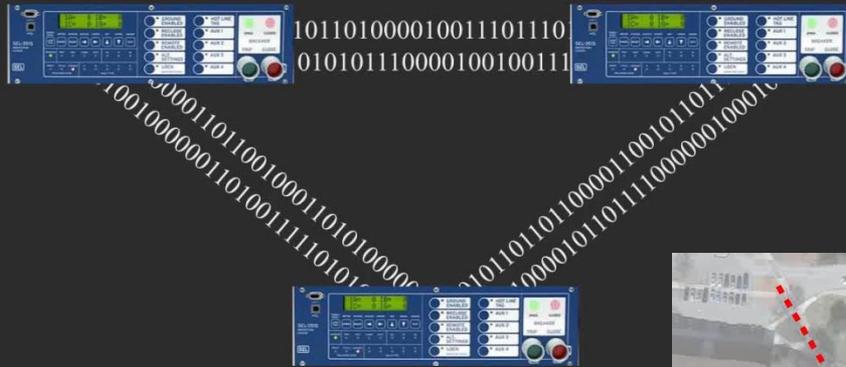


**Goal: Resiliency through redundancy**

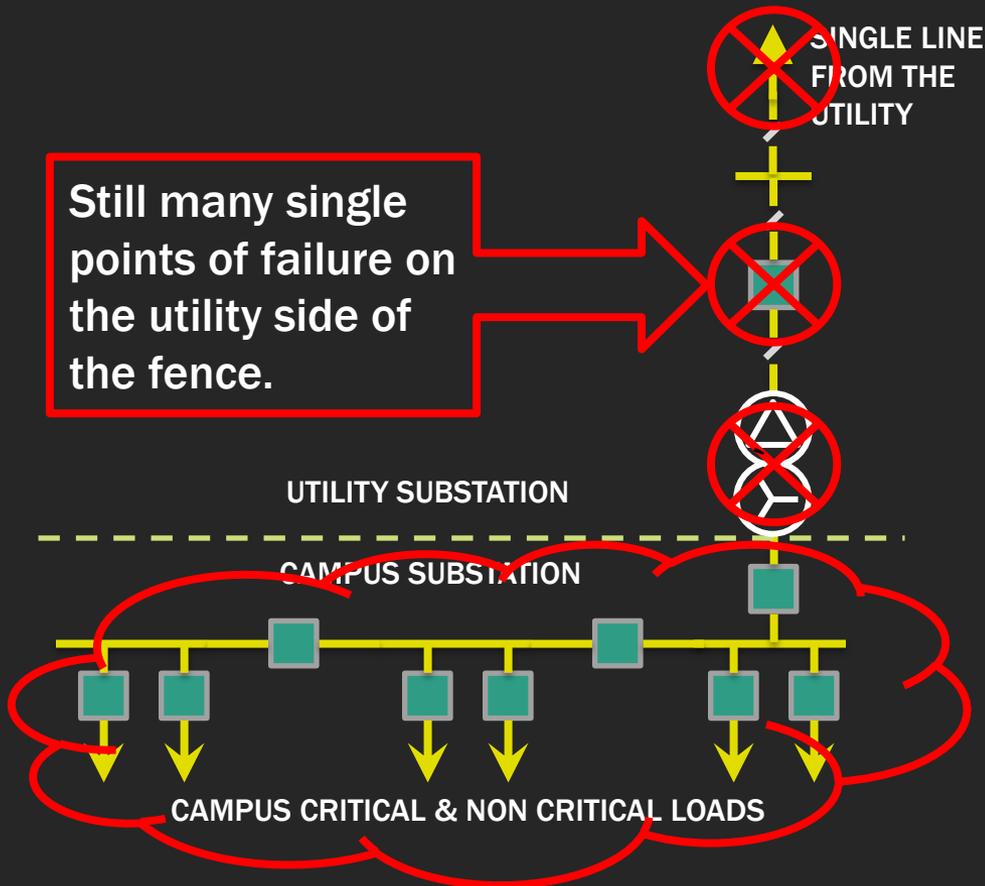
## Typical Solutions

- Loop-fed buildings
- Self healing
- Segmentable systems

# TYPICAL ELECTRICAL SYSTEM



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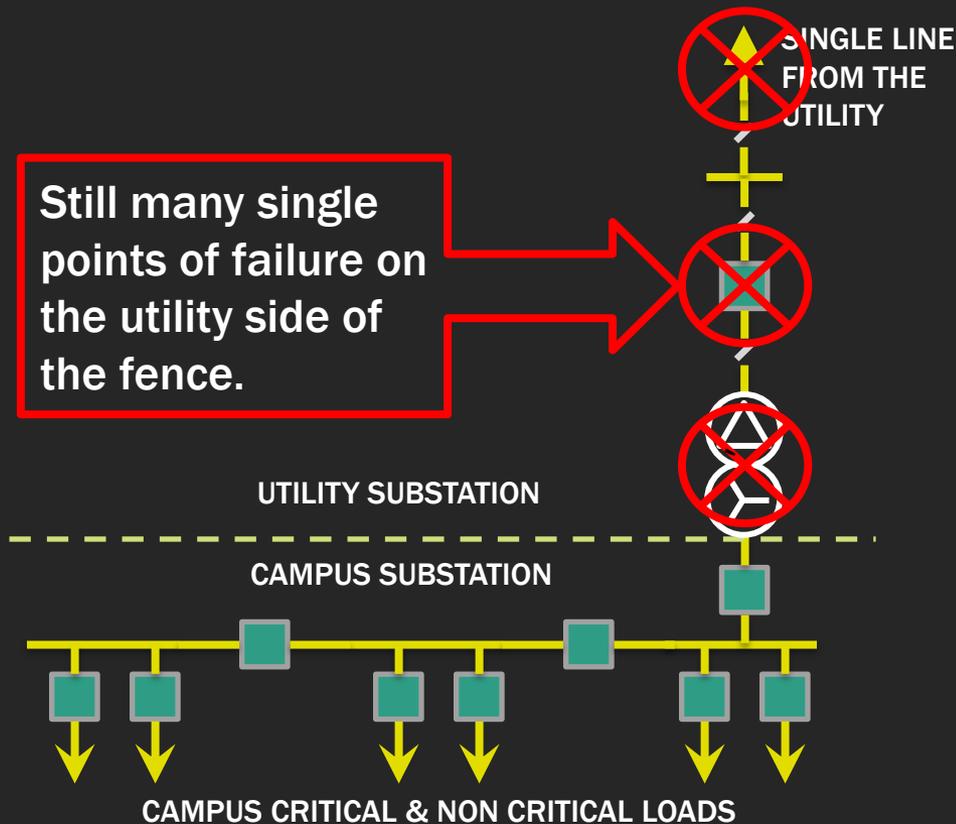


## Electrical System Bingo

- Loops
- Segmentation
- Self Healing Loops
- Smart Grid
- Microgrid

We have heard them all.  
Do they really get the resiliency that is desired?  
All "below the line" ...

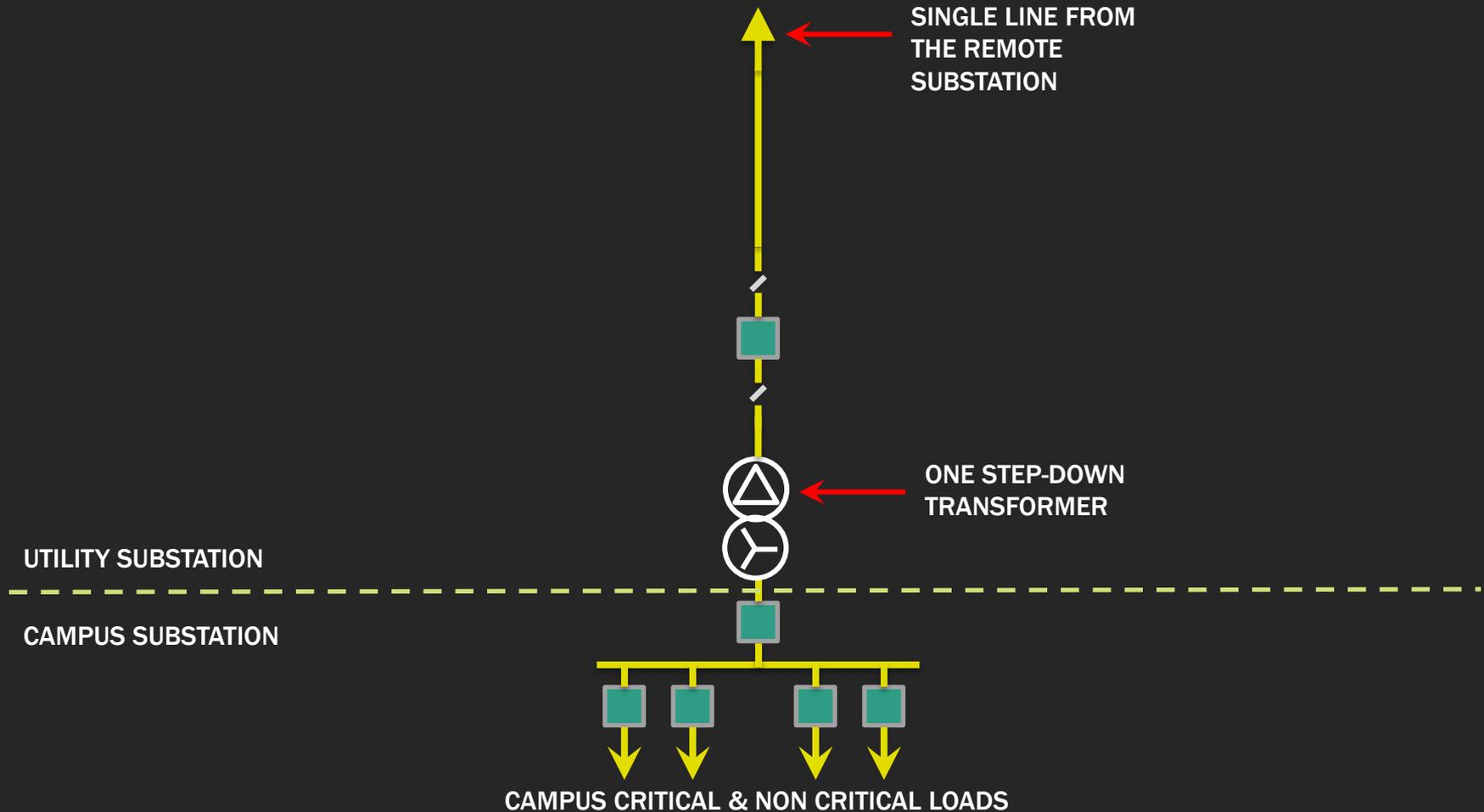
# TYPICAL ELECTRICAL SYSTEM



**Question:** If willing to spend large capital on campus side infrastructure, why not spend on utility side also?

**Challenges?** Fix the single transmission line service first if not done already. If they say no, ask again... and again...

# SUBSTATION CONFIGURATION: SINGLE RADIAL FEED

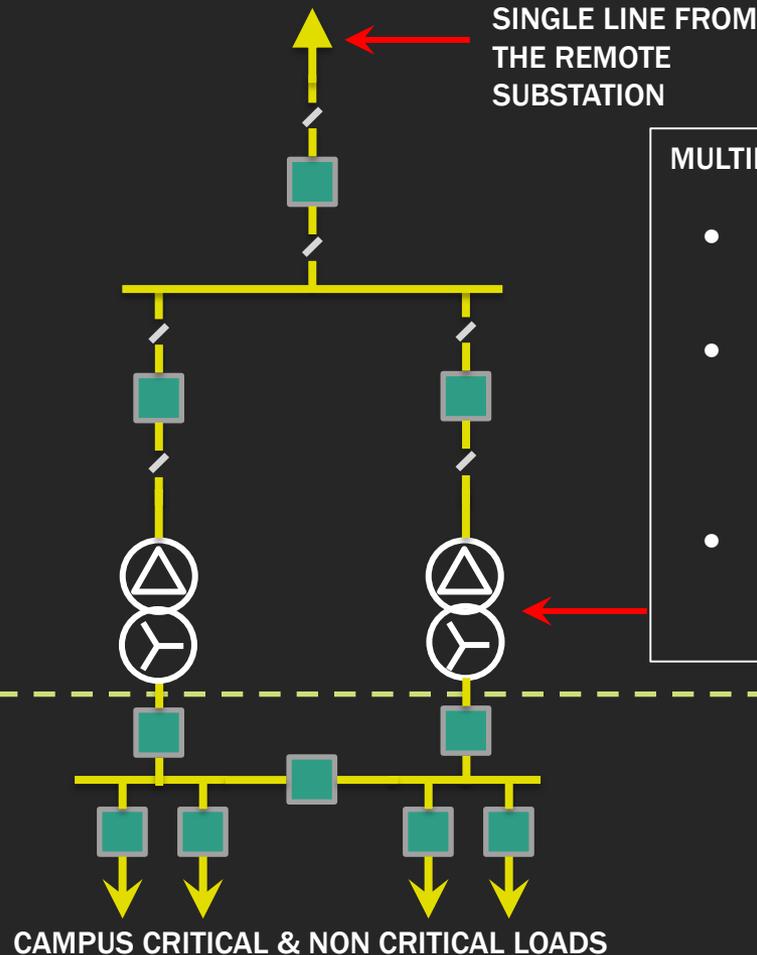


# SUBSTATION CONFIGURATION: SINGLE BUS SINGLE BREAKER

- ❖ LEAST RELIABLE
- ❖ LESS OPERATIONAL FLEXIBILITY
- ❖ LOW COST

UTILITY SUBSTATION

CAMPUS SUBSTATION

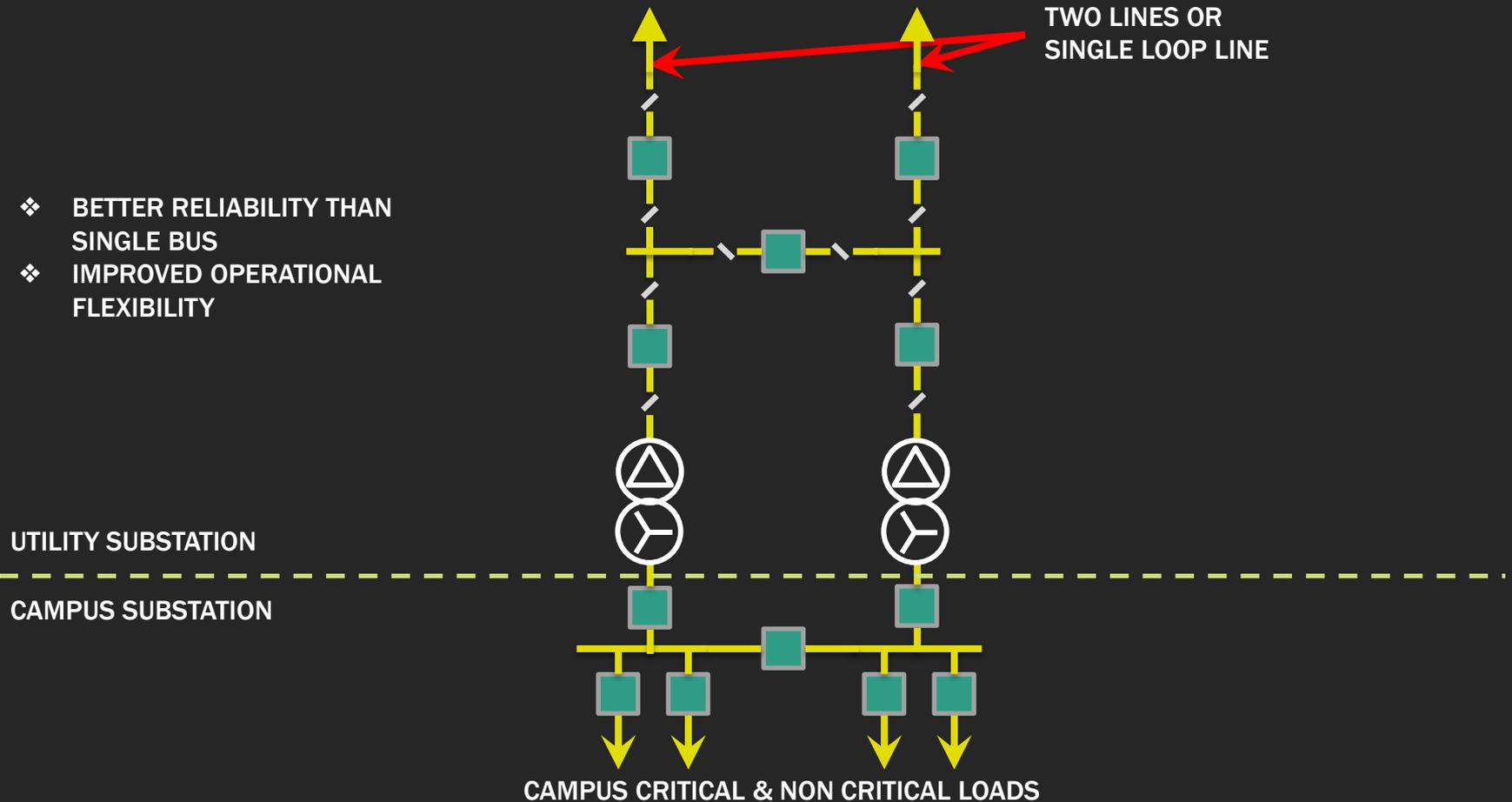


## MULTIPLE TRANSFORMERS

- OPERATED IN PARALLEL TO SHARE THE LOAD AT BASE RATING
- ONAF/OFAF ( OIL/AIR FORCED COOLING) RATED FOR MAXIMUM LOADING FOR TRANSFORMER OUTAGE CONDITIONS
- OPERATED IN N+1 CONFIGURATION I.E. WITH A STAND-BY TRANSFORMER

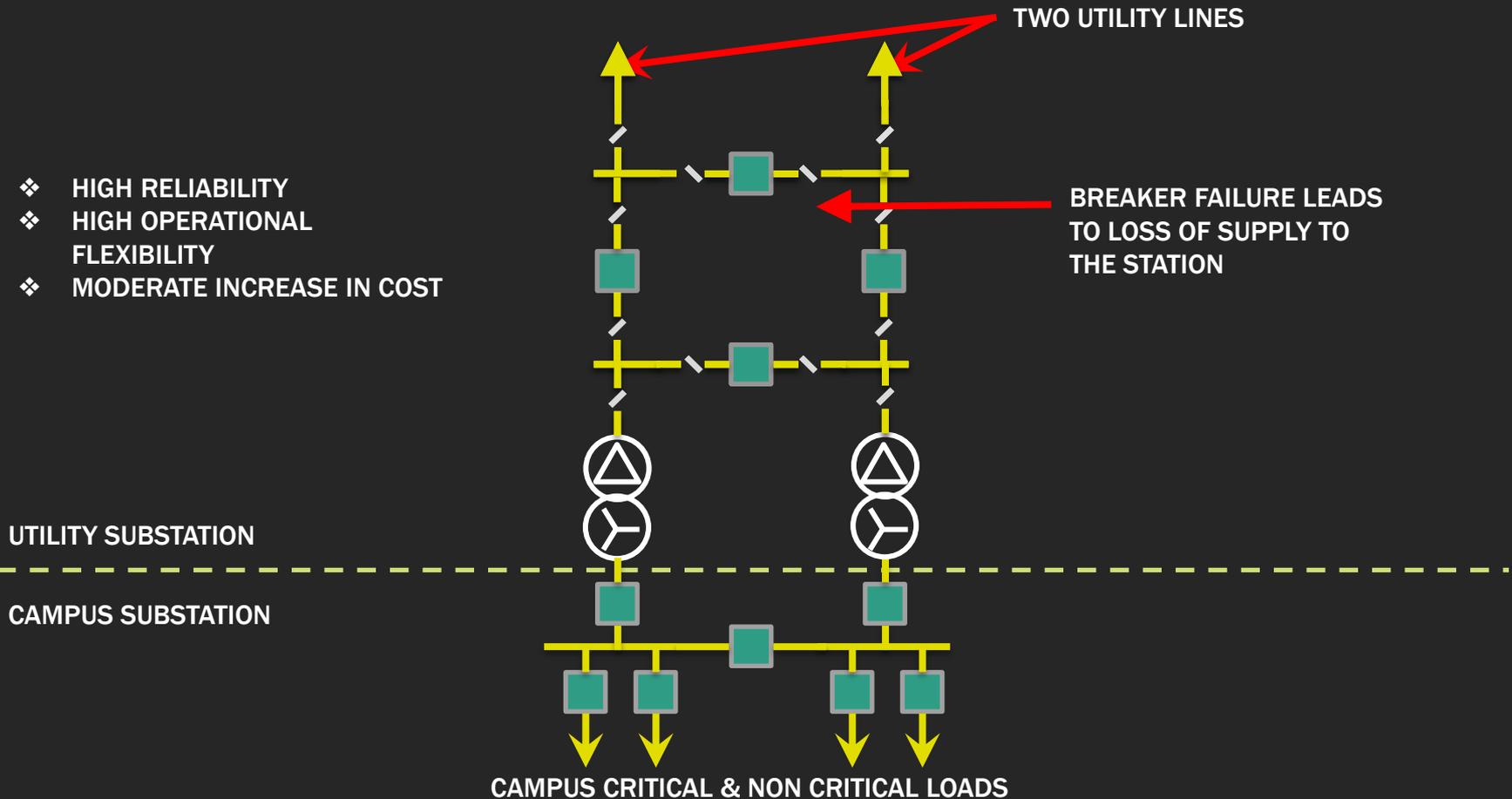
# SUBSTATION CONFIGURATION: SINGLE BUS WITH SECTION BREAKER

- ❖ BETTER RELIABILITY THAN SINGLE BUS
- ❖ IMPROVED OPERATIONAL FLEXIBILITY



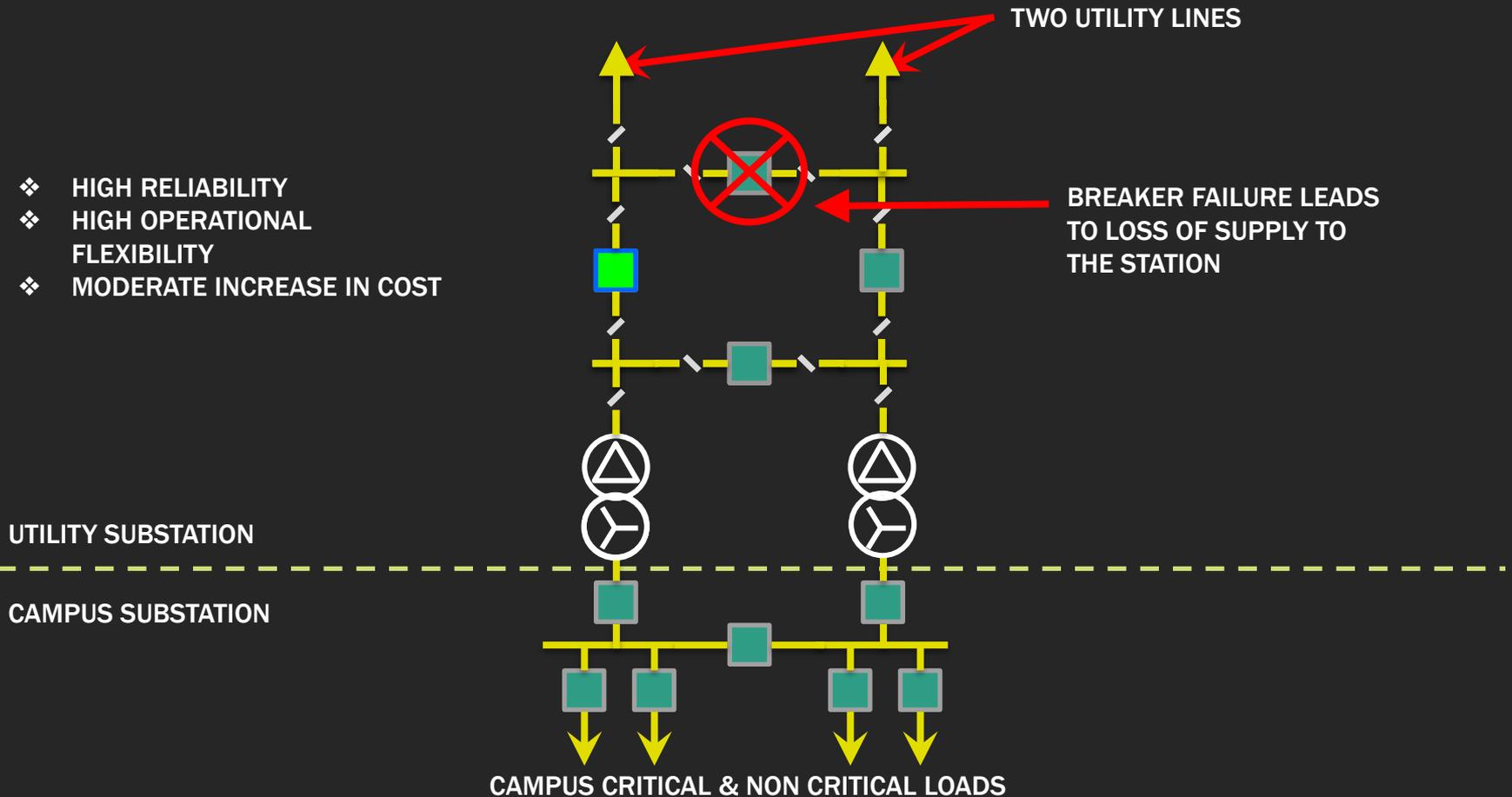
# SUBSTATION CONFIGURATION: RING BUS

- ❖ HIGH RELIABILITY
- ❖ HIGH OPERATIONAL FLEXIBILITY
- ❖ MODERATE INCREASE IN COST



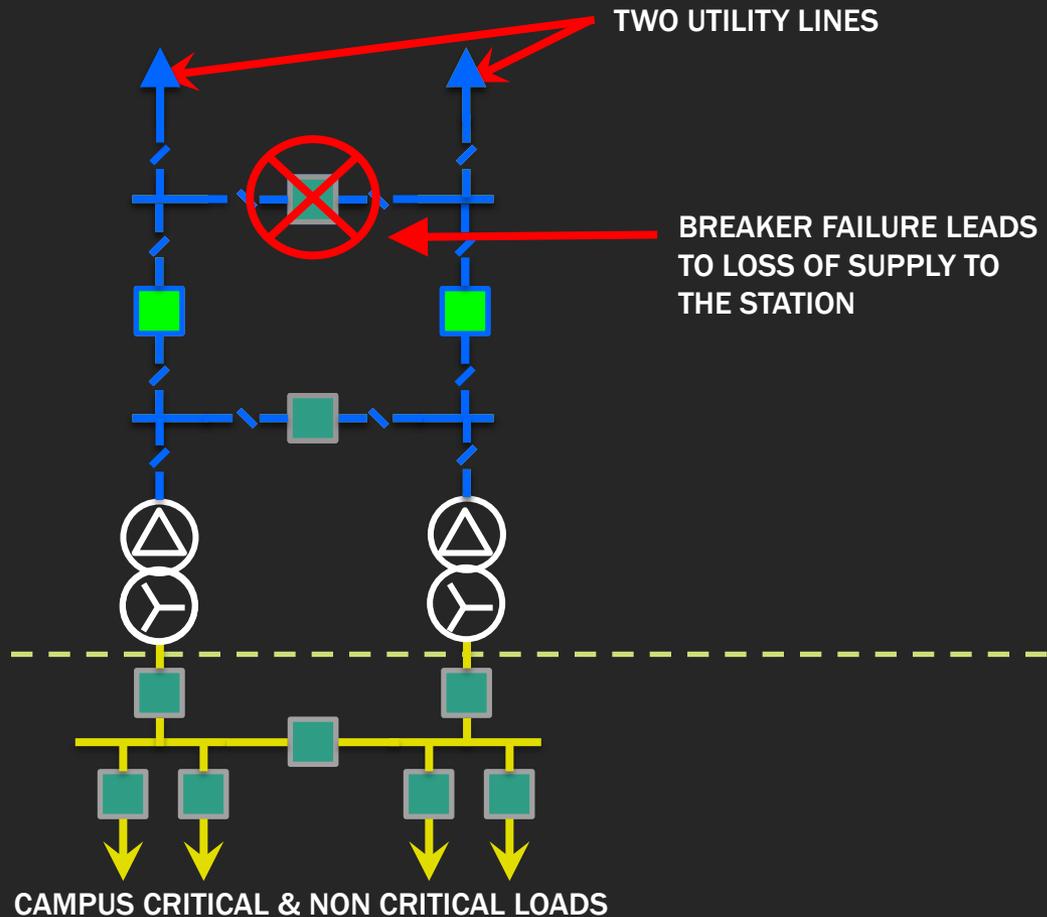
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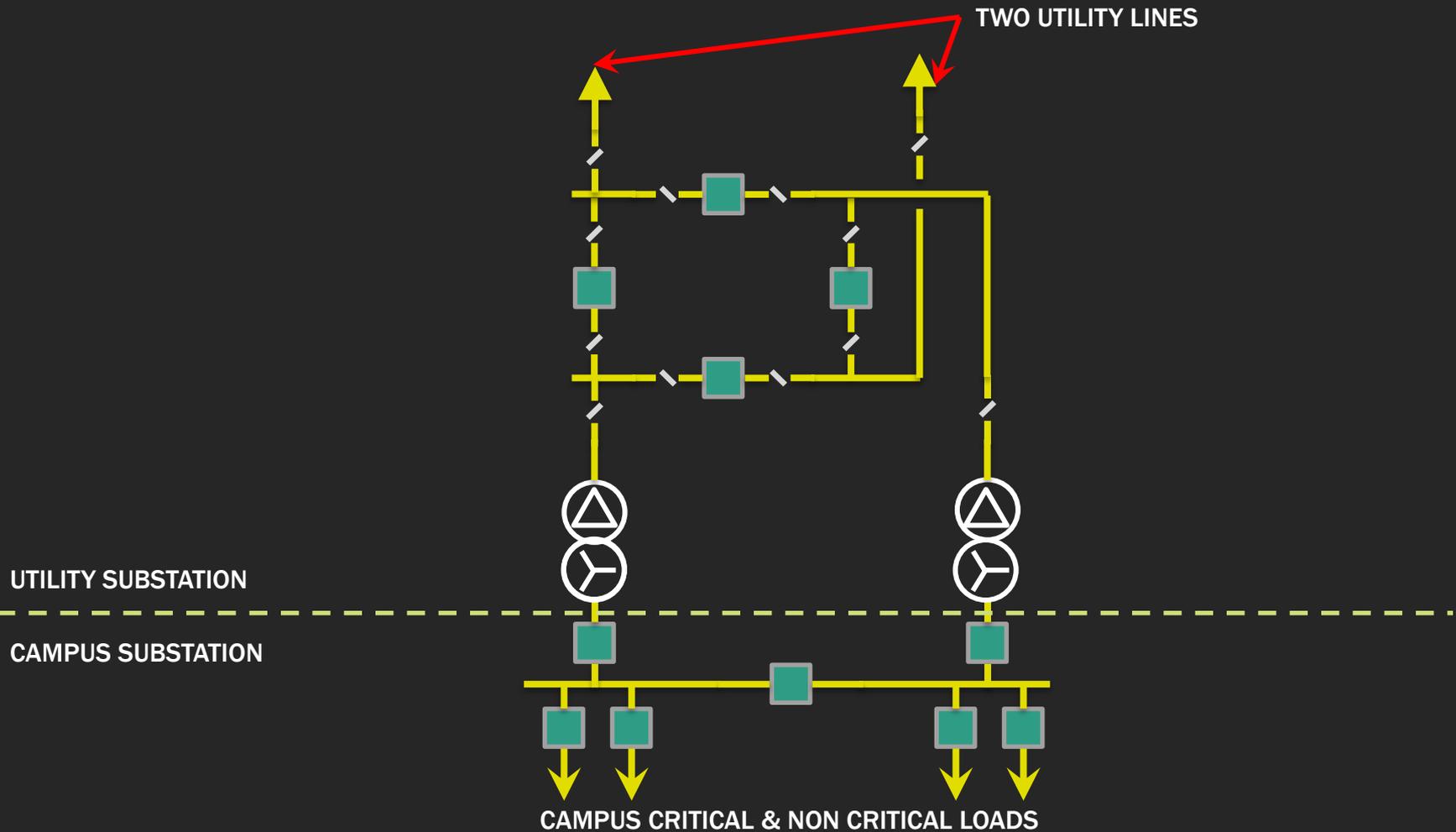


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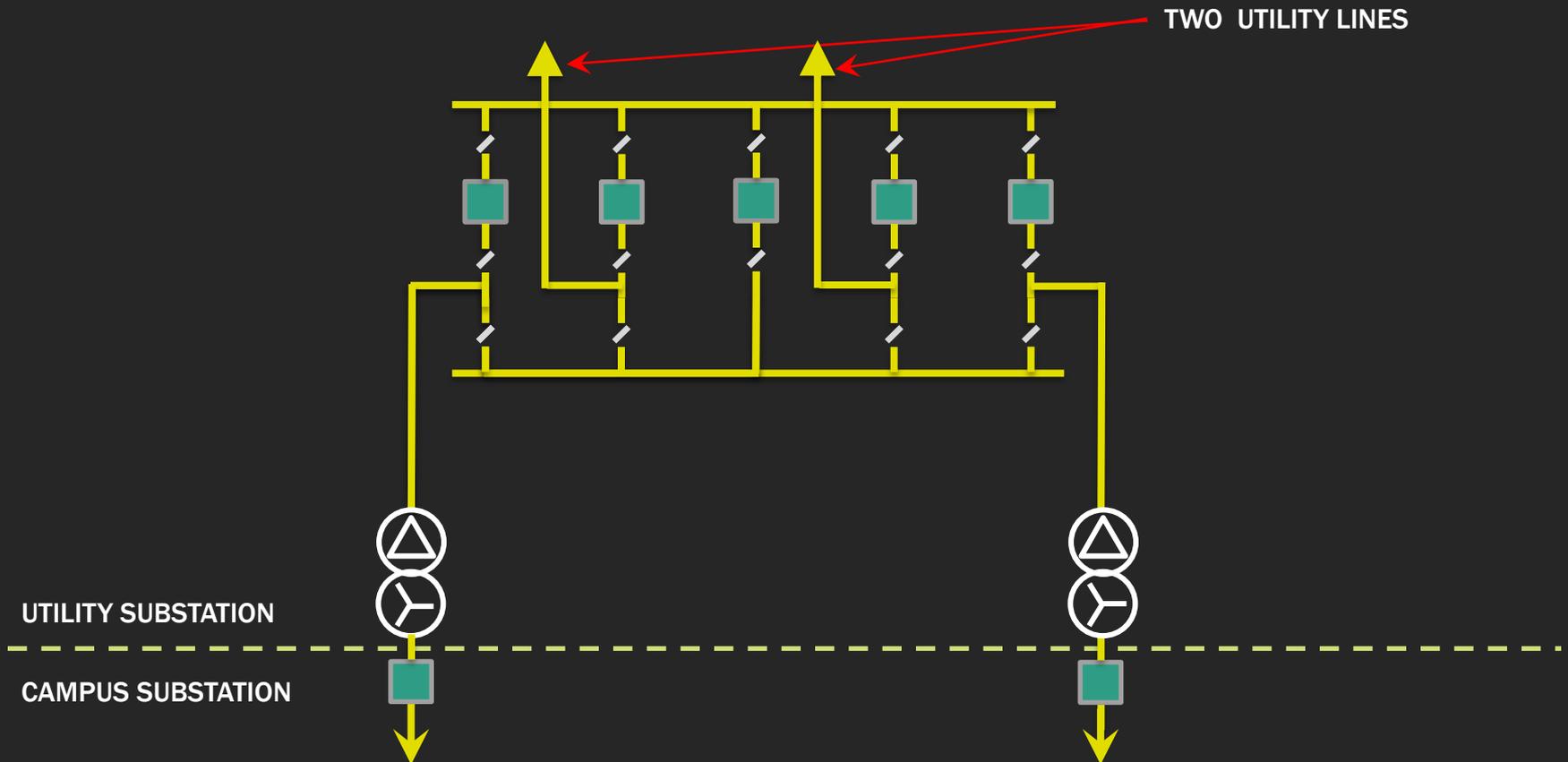
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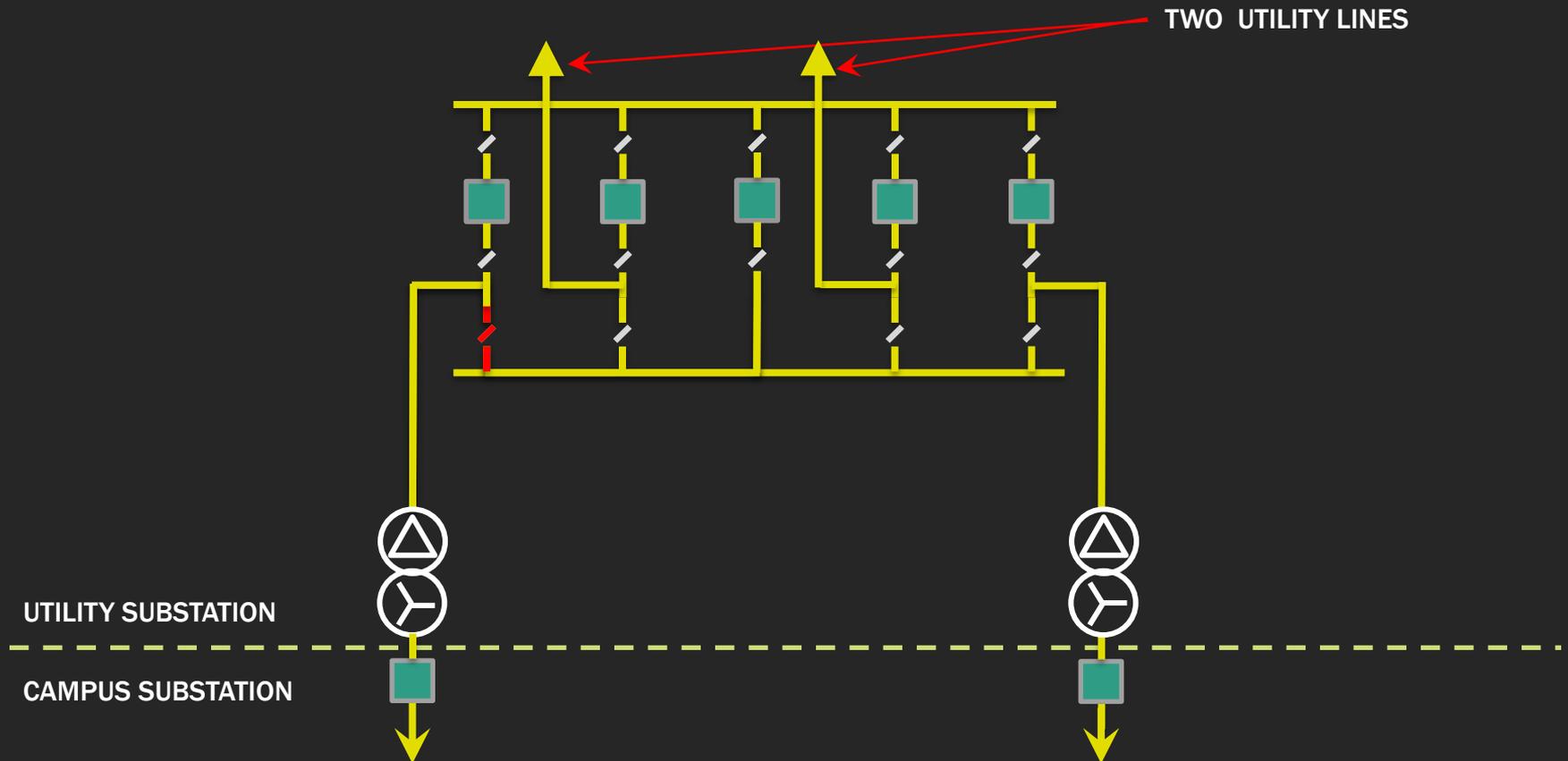
# SUBSTATION CONFIGURATION: RING BUS-ALTERNATIVE



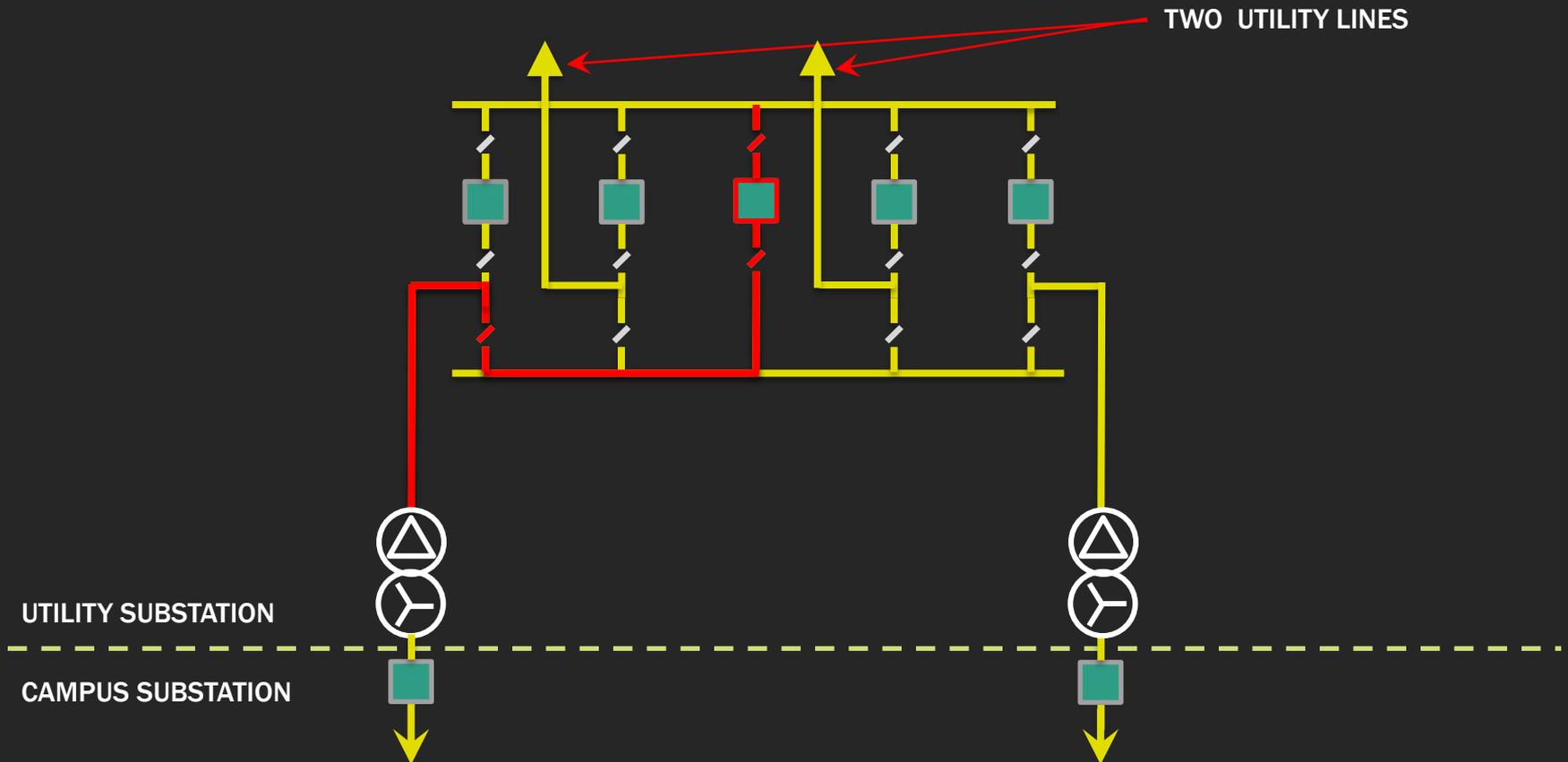
# SUBSTATION CONFIGURATION: MAIN & TRANSFER BUS



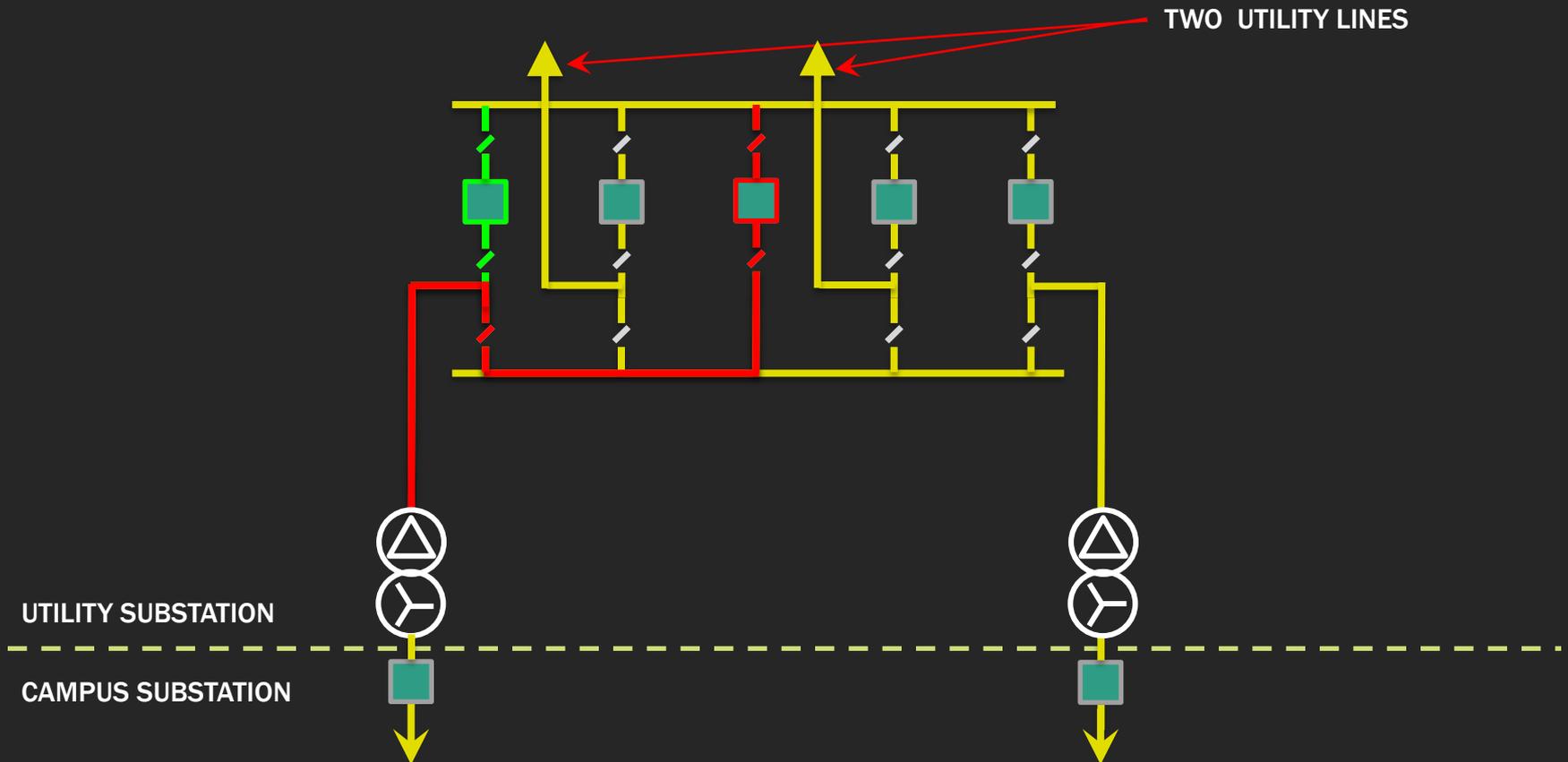
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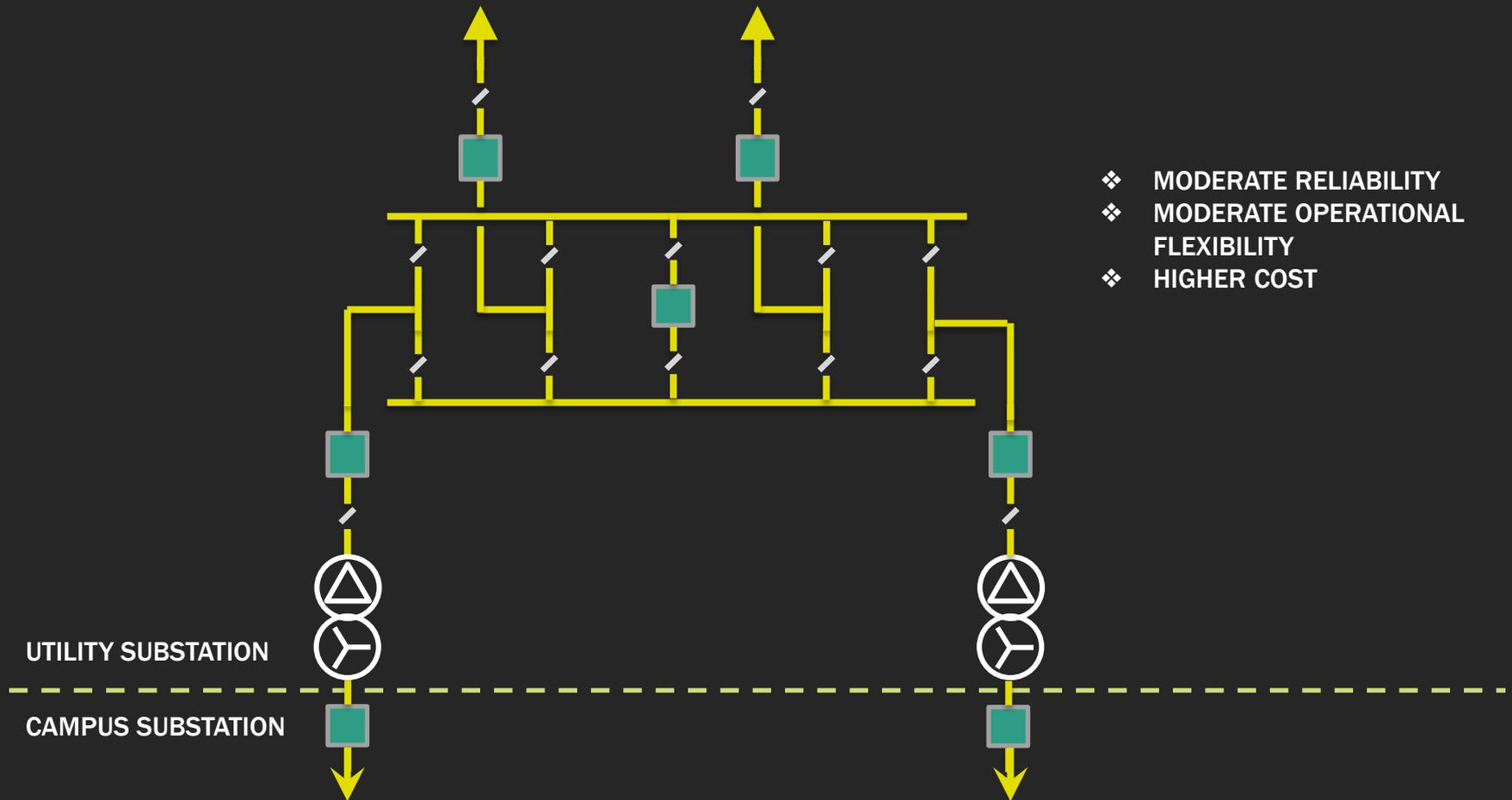
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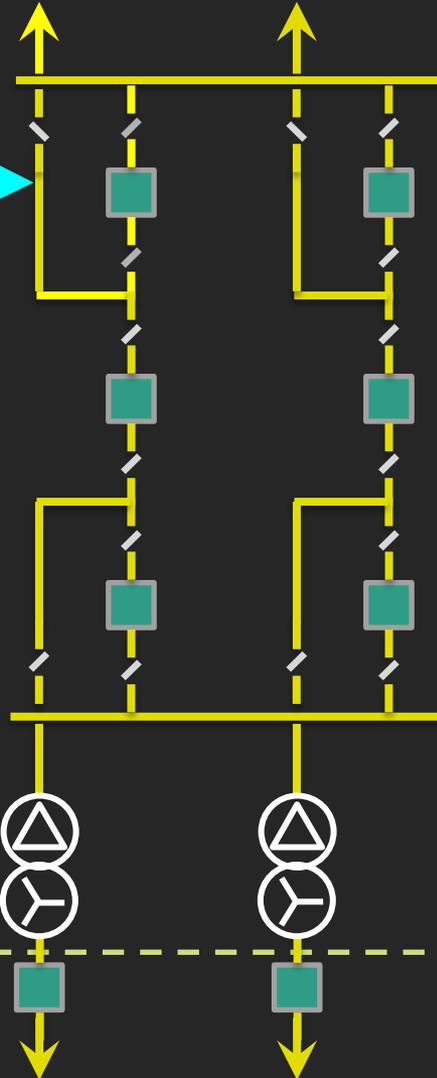
# SUBSTATION CONFIGURATION: DOUBLE BUS SINGLE BREAKER



- ❖ MODERATE RELIABILITY
- ❖ MODERATE OPERATIONAL FLEXIBILITY
- ❖ HIGHER COST

# SUBSTATION CONFIGURATION: B-1/2

BREAKER FAILURE  
DOES NOT AFFECT  
SUPPLY CONTINUITY



TWO UTILITY LINES

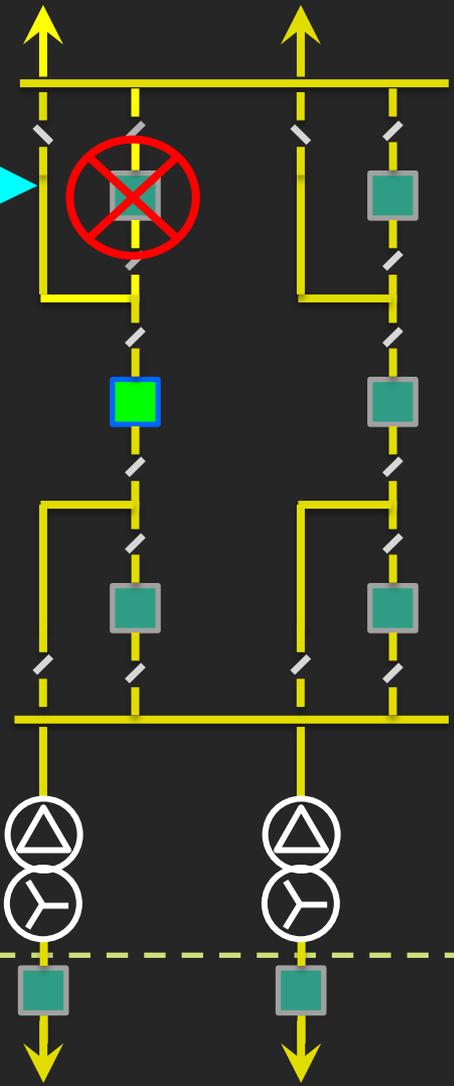
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UTILITY SUBSTATION

CAMPUS  
SUBSTATION

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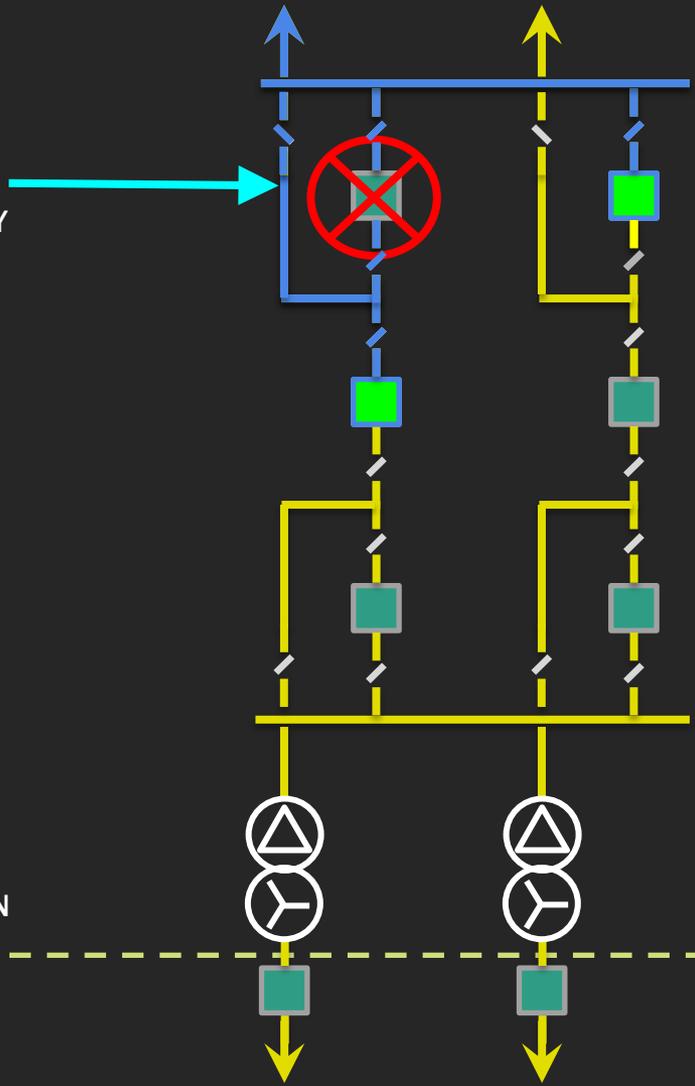
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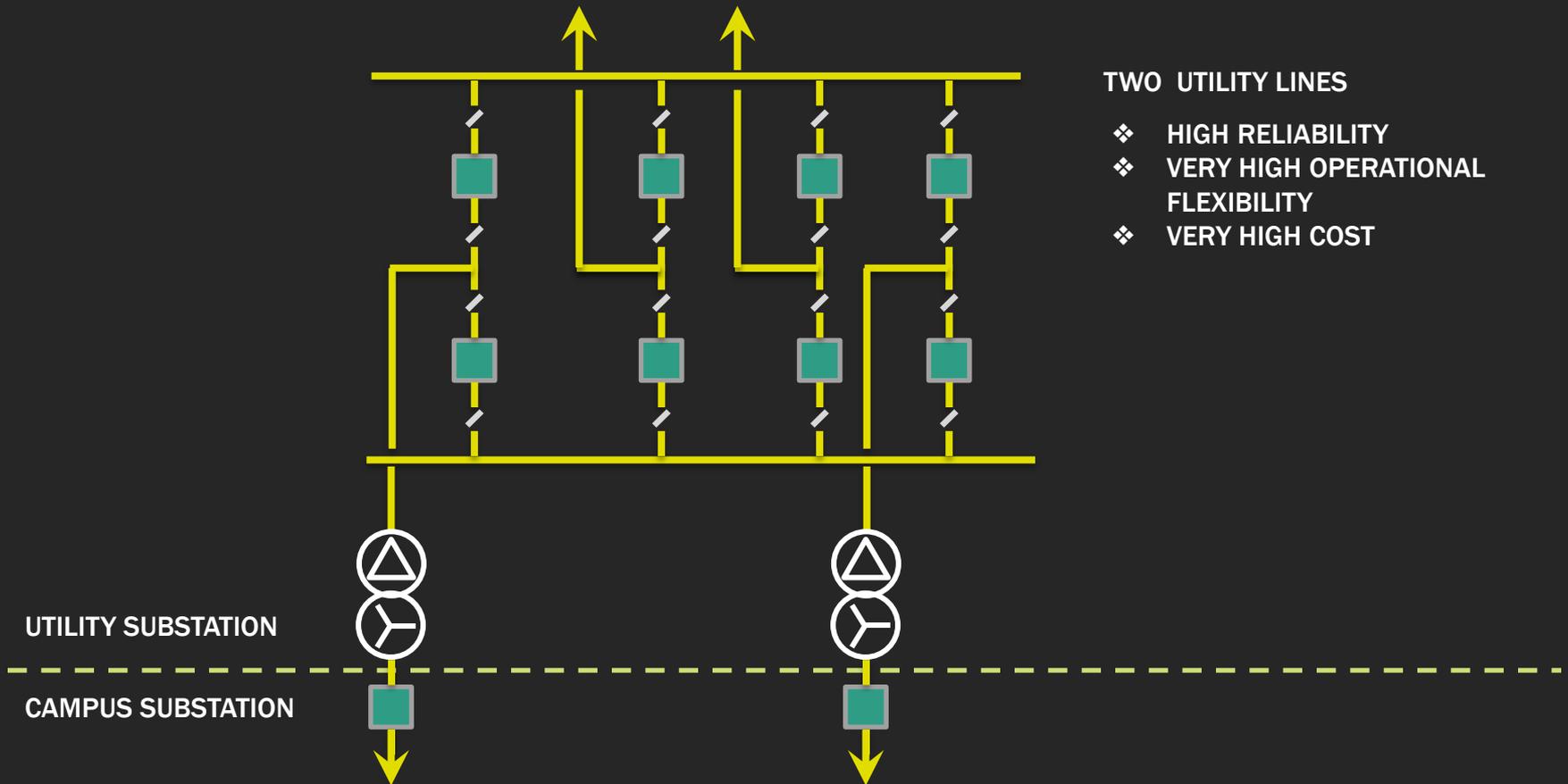
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UTILITY SUBSTATION

CAMPUS  
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# SUBSTATION CONFIGURATION: DOUBLE BUS DOUBLE BREAKER



# SUBSTATION CONFIGURATION: COMPARISON

Configuration	Reliability	Cost
Single Busbar	Least	100%
Single Busbar with Sectionalizer	Low	120%
Main & Transfer	Low	140%
Double Bus Single Breaker	Moderate	175%
Ring Bus	High	125%
<b>Breaker &amp; Half</b>	<b>High</b>	<b>145%</b>
Double Bus Double Breaker	High	190%

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**The level of service reliability is a risk management discussion and what can be afforded by the campus... what is an outage(s) worth?**

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